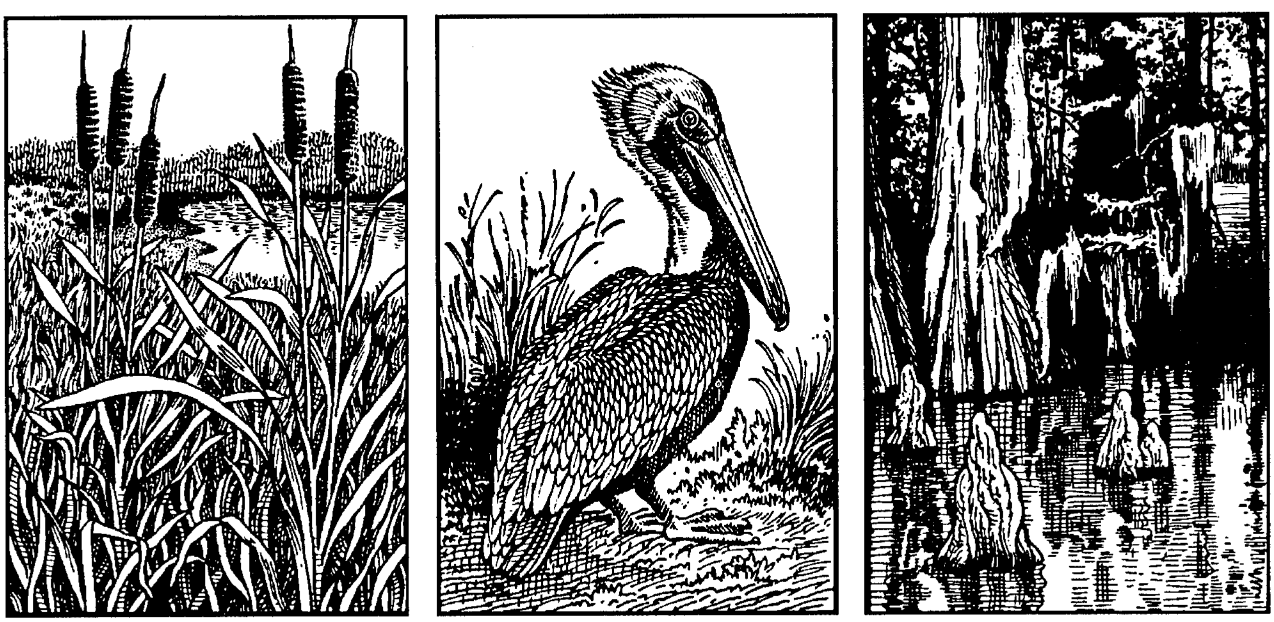
US Army Corps of Engineers
Waterways Experiment Station

Wetlands Research Program Technical Report WRP-RE-12

Monitoring Study, Eastern Neck Island National Wildlife Refuge

by John W. Gill, Peter McGowan, Leslie E. Gerlich



October 1995 – Final Report

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The following two letters used as part of the number designating technical reports of research published under the Wetlands Research Program identify the area under which the report was prepared:

	Task		Task
CP	Critical Processes	RE	Restoration & Establishment
DE	Delineation & Evaluation	SM	Stewardship & Management

Wetlands Research Program

Technical Report WRP-RE-12
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Monitoring Study, Eastern Neck Island National Wildlife Refuge

by John W. Gill, Peter McGowan, Leslie E. Gerlich

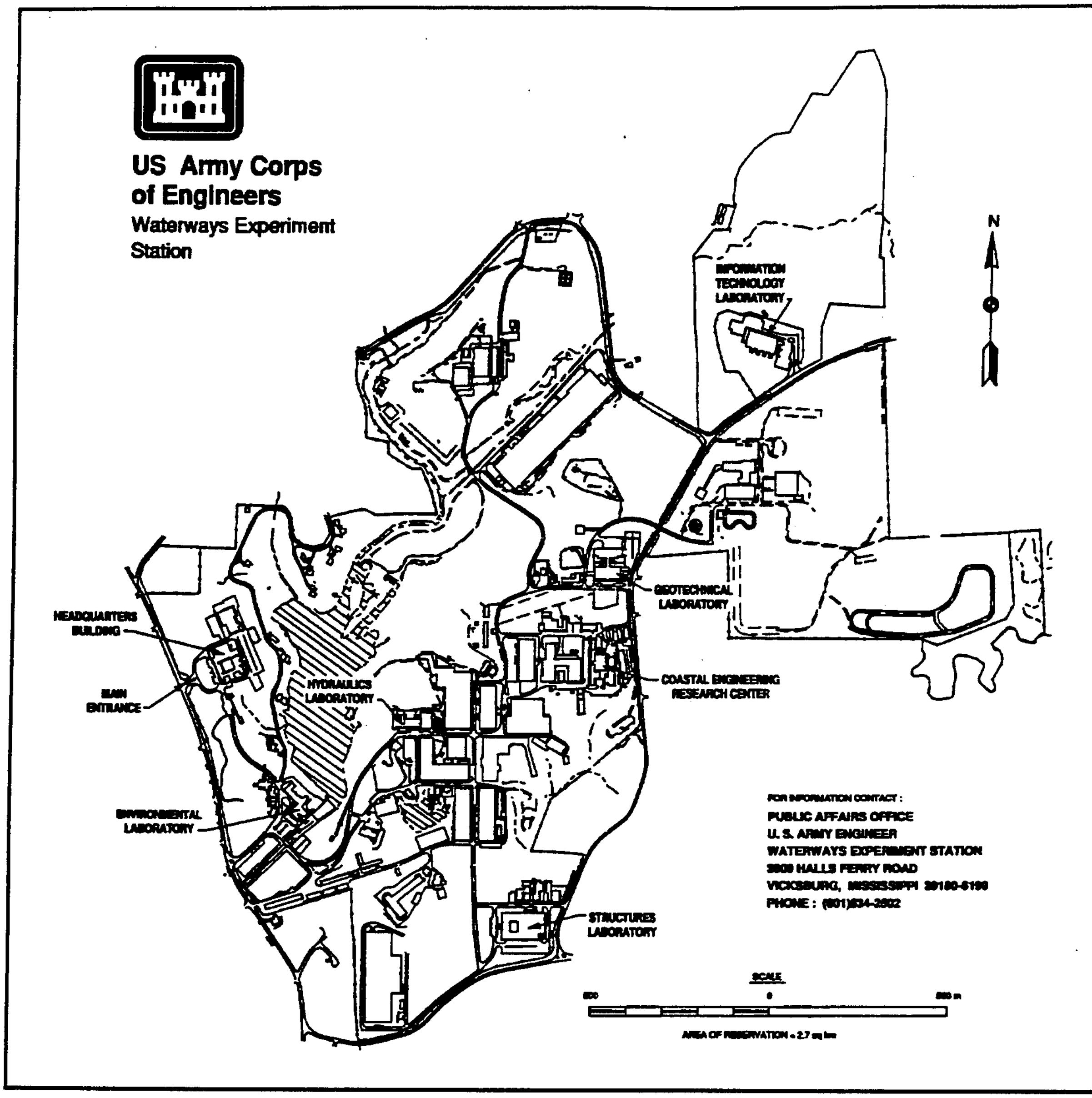
U.S. Fish and Wildlife Service
177 Admiral Cochrane Drive
Annapolis, MD 21401

Final report

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under WRP Work Unit 32761

Monitored by U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road, Vicksburg, MS 39180-6199



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Corps of Engineers Research Report Summary, October 1995

Dredged Material Use for Wetlands

Monitoring Study, Eastern Neck Island National Wildlife Refuge (TR WRP-RE-12)

ISSUE:

Methods are needed for environmentally preferable alternatives to unconfined, overboard dredged material disposal; preventing or minimizing erosional losses of ecologically valuable habitat; and creating wetland habitat.

RESEARCH:

The study monitored a wetland constructed by beneficial use of dredged material. Sandy dredged material was used to construct 2.02 hectares of estuarine emergent wetland. Segmented riprap and geotube breakwaters were used to protect the dredged material and an eroding portion of the adjacent Eastern Neck Island National Wildlife Refuge. Monitoring suggests that modifications to both the breakwater design and the planting materials and methods would have improved the rate of wetland development.

SUMMARY:

Study findings suggest the approach used at Eastern Neck, with modification, could be applied elsewhere in Chesapeake Bay for purposes of habitat protection and creation.

AVAILABILITY OF REPORT:

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About the Authors:

John W. Gill is a biologist and Peter McGowan and Leslie E. Gerlich are biology technicians with the U.S. Fish and Wildlife Service in Annapolis, MD. Point of contact at WES is Dr. Stephen T. Maynord, a research hydraulic engineer at the Hydraulics Laboratory at 601-634-3284.

Contents

List of Figures

Preface

The work described in this report was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Restoration and Establishment of Wetlands Task Area of the Wetlands Research Program (WRP). The work was performed under Work Unit 32761, "Restoration and Establishment Field Demonstrations," for which Dr. Mary Landin was Technical Manager. Ms. Denise White (CECW-ON) was the WRP Technical Monitor for this work.

Mr. Dave Mathis (CERD-C) was the WRP Coordinator at the Directorate of Research and Development, HQUSACE; Dr. William L. Klesch (CECW-PO) served as the WRP Technical Monitors' Representative; Dr. Russell F. Theriot, U.S. Army Engineer Waterways Experiment Station (WES), was the Wetlands Program Manager. Dr. Landin, WES Environmental Laboratory (EL), was the Task Area Manager.

The work was performed at U.S. Fish and Wildlife Service (USFWS). This report was prepared by Messrs. John W. Gill and Peter McGowan, and Ms. Leslie E. Gerlich under the supervision of Mr. John P. Wolflin, all of the USF WS, under contract/support agreement No. WESCW-93-090. The work was performed under Research Area 3, "Coastal, Shoreline, and Channel Protection," of WRP Work Unit 32761, for which Dr. Stephen T. Maynord and Mr. Jack E. Davis were Principal Investigators. Dr. Maynord worked under the general supervision of Mr. Frank A. Herrmann, Jr., Director, Hydraulics Laboratory (HL), WES; Mr. Richard A. Sager, Assistant Director, HL; Mr. Glenn A. Pickering, Chief of the Hydraulic Structures Division (HSD), HL; and Mr. Noel R. Oswalt, Chief, Spillways and Channels Branch, HSD. Mr. Davis worked under the general supervision of Dr. James R. Houston, Director, Coastal Engineering Research Center (CERC), WES; Mr. Charles C. Calhoun, Jr., Assistant Director, CERC; Mr. Thomas W. Richardson, Chief, Engineering Development Division (EDD), CERC; Ms. Joan Pope, Chief, Coastal Structures and Evaluation Branch (CSEB), EDD; and Dr. Yen-Hsi Chu, Chief, Engineering Applications Unit, CSEB, EDD.

The following individuals are acknowledged for their support of this project: Mr. Marty Kaehny, Refuge Manager at Eastern Neck Island National Wildlife Refuge (ENWR); Ms. Kathy Owens, Refuge Operations Specialist, ENWR; Ms. Kimberly Bucklew, Office Assistant, ENWR; Mr. Ken Fletcher,

Engineering Equipment Operator, ENWR; Mr. Glenn G. Page, Habitat Restoration Program Manager, Alliance for the Chesapeake Bay; volunteer planters from the Maryland Department of Natural Resources and from the Chesapeake Bay Field Office, USFWS; and Congressman Wayne T. Gilchrist (R, Maryland).

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	0.4047	hectares
feet	0.3048	meters
inches	25.4	millimeters
tons (long, mass)	1,016.647	kilograms

1 Introduction

Background

Past studies have shown the Chesapeake Bay shoreline is severely eroding in many areas (U.S. Army Engineer Districts, Baltimore and Norfolk, 1986; Virginia Institute of Marine Science (VIMS) 1977; Singewald 1949). Particularly hard hit are numerous islands located off the eastern shore. Considering only the middle portion of eastern Chesapeake Bay, since colonial times at least 4,375 island hectares have been lost (Table 1).

Isolation, lack of human disturbance, and fewer predators make Chesapeake Bay islands productive nesting sites for colonial waterbirds, waterfowl, and the Federally listed endangered bald eagle (*Haliæetus leucocephalus*). In Maryland, with the exception of the great blue heron (*Ardea herodias*) and least tern (*Sterna albifrons*), all heron and larid colonies occur on island sites.[1] Estimates of Maryland's 1993 colonial waterbird breeding population sizes are presented in Table 2.

The refuge is a 950-ha island located at the mouth of the Chester River on the eastern shore of Chesapeake Bay in Kent County, Maryland (Figure 1). Eastern Neck was established in 1962 to provide wintering and migration habitat for waterfowl. The refuge now provides habitat for a variety of migrating and resident wildlife species, including the Federally listed endangered Delmarva fox squirrel (*Sciurus niger cinereus*) and bald eagle.

Habitat and facility lands are listed in the following tabulation. Refuge management activities are directed toward providing migrating and wintering waterfowl populations, shorebirds, and endangered species with optimum feeding and/or nesting habitat. Cooperative farming, wood duck nest boxes, banding, surveys, water level management in green tree reservoirs, and habitat manipulation are some of the refuge programs that benefit waterfowl and shorebirds. Current populations of concern include Canada geese (*Branta canadensis*), black ducks (*Anas rubripes*), wood ducks (*Aix sponsa*), and the American woodcock (*Philohela minor*). The Delmarva fox squirrel and bald

[1] D. F. Brinker, Personal Communication, 1993, Department of Natural Resources, Annapolis, MD.

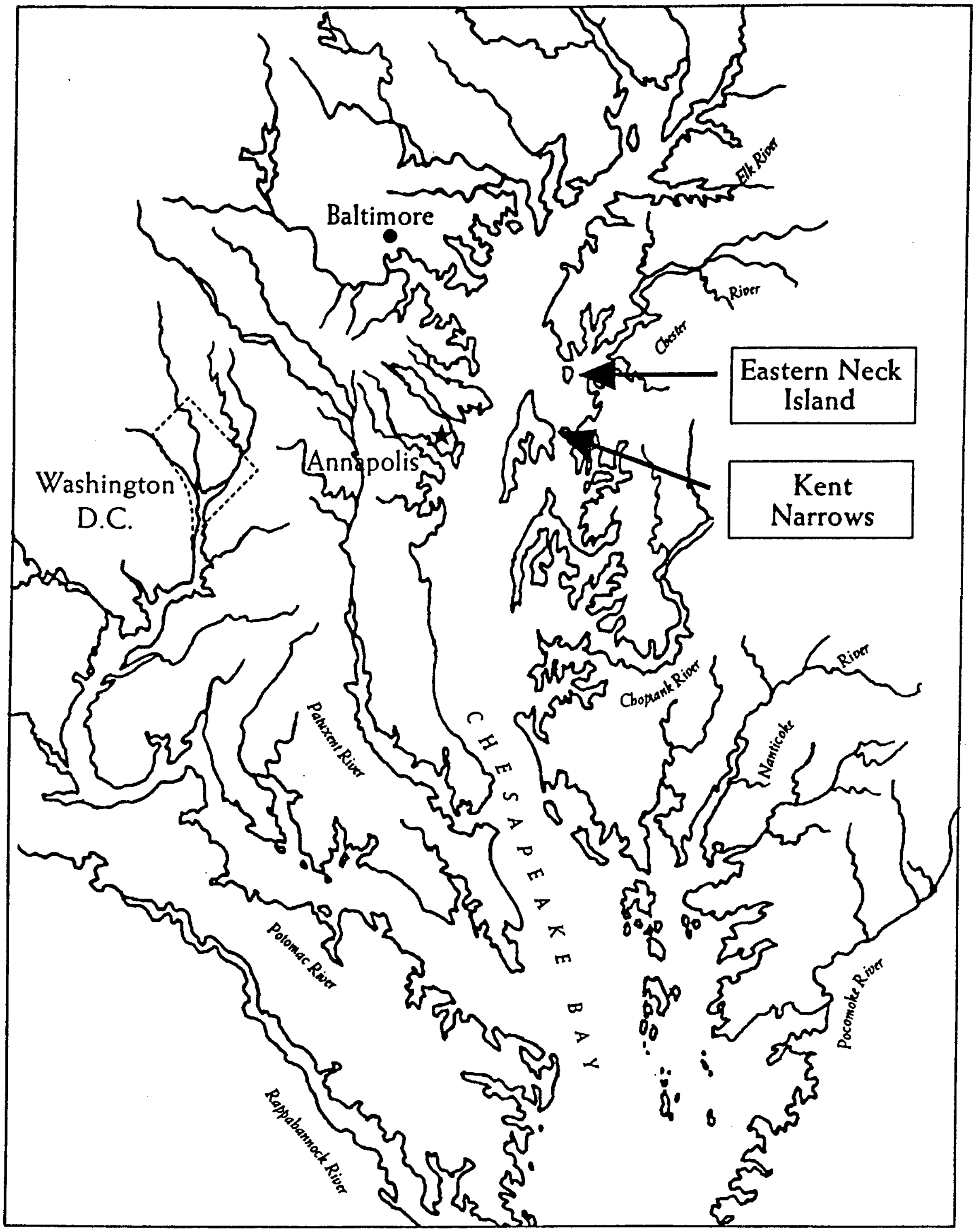

Figure 1. Location map

Classification	Size, ha
Saltmarsh	415
Cropland	210
Woodland	225
Grassland	77
Open water	15
Administrative	11

eagle are major determining factors in every management decision. Programs such as the annual deer hunt, prescribed burns, population counts, disturbance avoidance, cooperative farming, and fox squirrel nest boxes are part of an ongoing effort to assist in the recovery of these species.

Erosion of the western shore of the refuge has become an increasingly serious problem. In some areas the shoreline has receded by as much as 3 m per year.[1] Estimates indicate that nearly 0.4 ha of land is lost on the refuge western shore each year (Offshore and Coastal Technologies 1991). This equates to approximately 2,541,617 kilograms (2,500 tons) of sediment annually entering the bay from erosion.

In 1989, the U.S. Congress appropriated funds to design and construct shoreline erosion control measures on the refuge western shore. Two reaches of the western shoreline were identified as exhibiting the highest rates of erosion (Figure 2). Reach 1 extends 304 m from Ingleside picnic area to the northwest corner of the island. Reach 2 extends 1,733 m from the northwest corner to Wickes Beach. After several erosion control alternatives were evaluated, a series of stone (riprap), offshore breakwaters was selected as the most environmentally sound approach. Construction began in March of 1992.

Because bids were more favorable than predicted, additional funds during July of 1992 were available from the original $2.9 million appropriation. It was decided to extend shoreline protection immediately south of Reach 2, to include Wickes Beach and Cabin Cove areas. Cabin Cove encompasses the present study area (Figure 3).

Extended shoreline protection in the study area consists of five stone breakwaters (constructed of 1.5- to 3-ton[2] stones) located a maximum of 122 m offshore in depths of 0.76 m mean low water (mlw), and oriented parallel to the shoreline. Breakwaters are trapezoidal in cross section, 30.4 m long, with a top height of 1 m above mean high water (mhw). Including a revetment tied into the shoreline and 15-m breaks between breakwaters, the project provides approximately 608 m of additional shoreline protection.

[1] T. Goettel, Personal Communication, U.S. Fish and Wildlife Service, Hadley, MA.
[2] A table of factors for converting non-SI units of measurement to SI units is found on page ix.

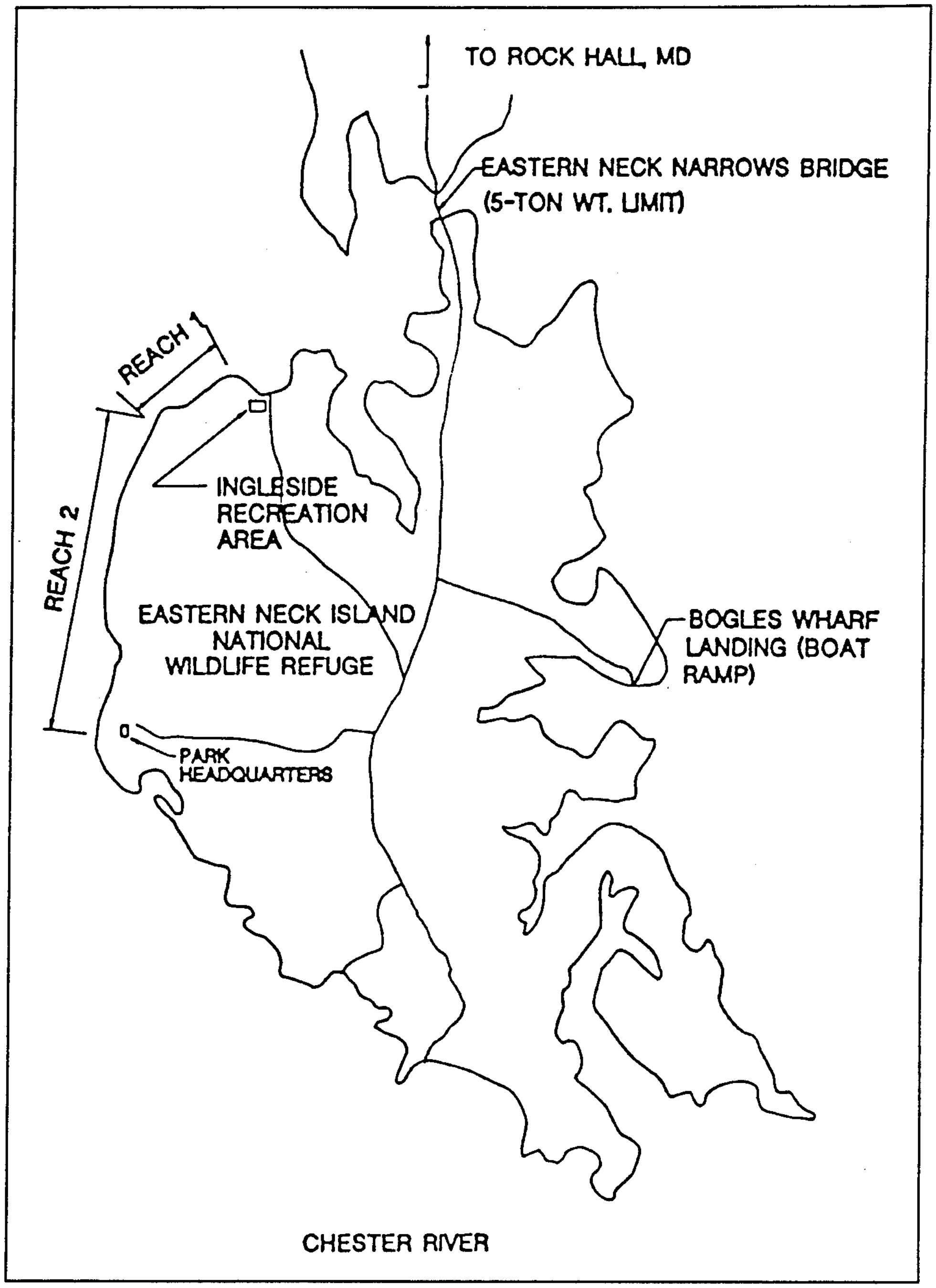

Figure 2. Site map

Originally, engineering consultants recommended shoreline areas landward of the breakwaters be armored with cobble from mhw to mlw. Before construction of this phase began, the U.S. Fish and Wildlife Service (USFWS) was approached by the U.S. Army Engineer District, Baltimore, concerning availability of the refuge as a wetland creation/"beneficial use" of dredged material demonstration site. With the soon-to-be-constructed breakwaters providing protection, Cabin Cove would be the most suitable demonstration

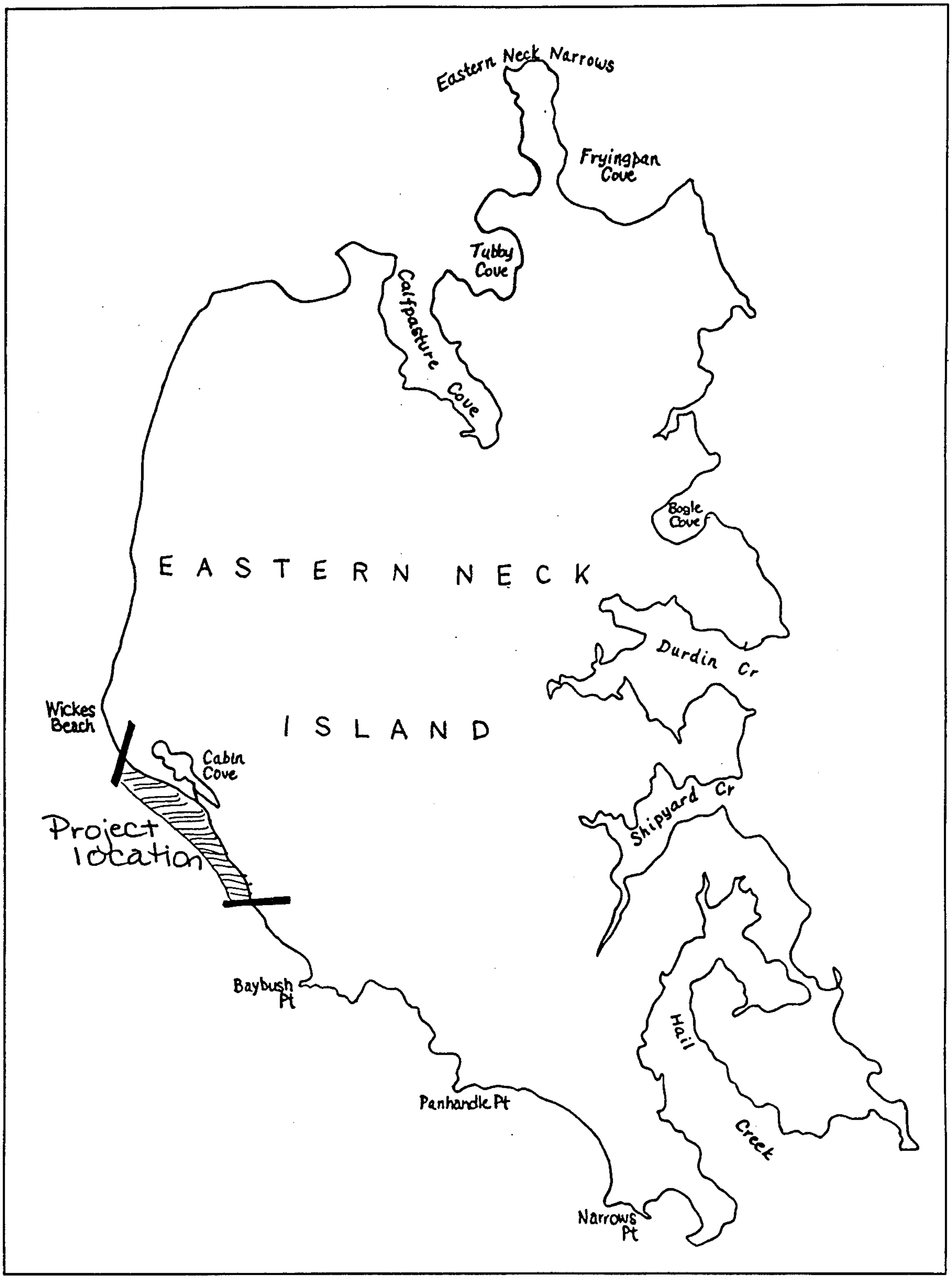

Figure 3. Study area

shoreline. Preliminary site investigations indicated that resource tradeoffs associated with the conversion of shallow water to estuarine emergent wetland and intertidal zones would be minimized (e.g., area devoid of submerged aquatic vegetation, sessile shellfish, critical fisheries habitat). Use of dredged material and wetland vegetation to stabilize the shoreline eliminated the need to place cobble in the intertidal zone, resulting in a $60,000 saving to the USFWS.[1] The decision to proceed also provided the Corps with a badly needed placement site for material coming from the scheduled maintenance dredging of the Chester River channel.

The Chester River channel is located at the northern entrance to Kent Narrows, approximately 7.2 km south of the refuge (Figures 1 and 4). Kent Narrows is used as a shortcut by boaters between popular anchorages found on the Chester River and tributaries to Eastern Bay, and is one of the busiest thoroughfares in the Maryland portion of Chesapeake Bay.

The Long Point section of the Chester River channel had shoaled to controlling depths averaging 0.6 to 1.5 m, hindering navigational access in and out of Kent Narrows. Maintenance dredging reestablished a channel 2.1 m deep along approximately 1,611 m of the 23-m-wide channel. Hydraulic dredging generated approximately 34,380 cu m of predominantly fine grained sand.

Dredged material was transported by hydraulic pipeline to Cabin Cove, and deposited in shallow waters landward of the five offshore breakwaters. The material was mounded up to 0.304 m above mhw at the original shoreline, and planted with smooth cordgrass (*Spartina alterniflora*) and saltmeadow hay (*Spartina patens*). In addition to the breakwaters, two geotextile tubes (Geotubes) were filled with dredged material and aligned with the breakwaters.

Project and Monitoring Objectives

The objectives of the wetland creation and erosion control project were as follows:

a. Provide an environmentally preferable dredged material placement site as an alternative to unconfined, overboard disposal.

b. Stop or minimize erosional losses of ecologically important habitats.

c. Create wetland habitat.

Although shallow-water areas converted to estuarine emergent wetlands were formerly wetlands (lost to erosion), project objectives did not include "wetland restoration." The fact that the study site supports wetland vegetation does not

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[1] R. Zepp, Personal Communication, U.S. Fish and Wildlife Service, Annapolis Field Office, Annapolis, MD.

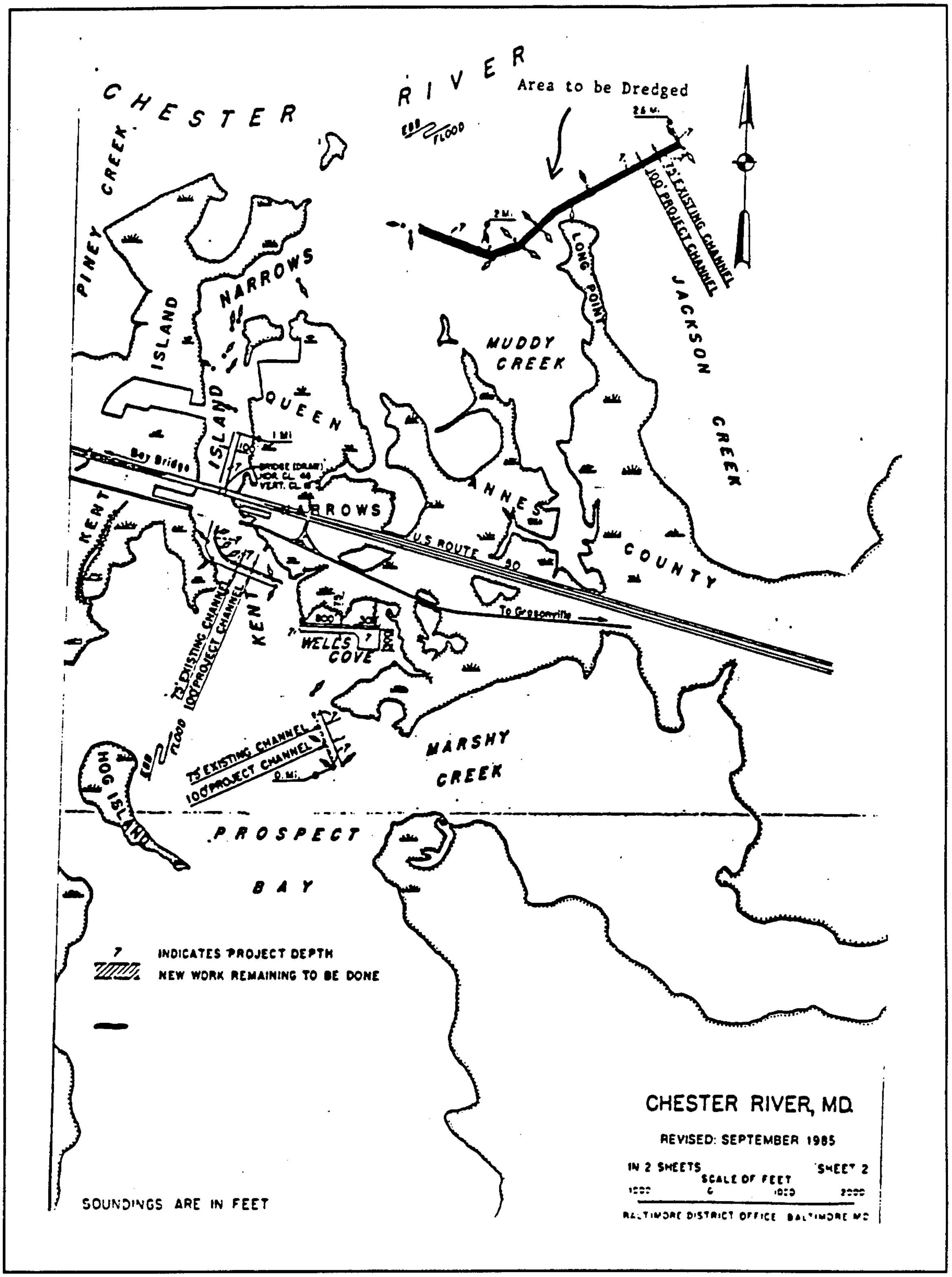

Figure 4. Location of Kent Narrows and Chester River Channel

mean the created wetland provides all functional wetland values and attributes (e.g., estuarine energetics, nutrient cycling, microbial rhizome associations, etc.). Monitoring did include some qualitative comparisons with natural wetland communities. However, a functional assessment and comparison of the created wetland were not possible given the scope and duration of this two-growing-season monitoring effort.

The objectives of the monitoring study were as follows:

a. Measure growth and survival of planted smooth cordgrass and saltmeadow hay.

b. Document plant colonization.

c. Document fish and wildlife utilization.

d. Measure dredged material elevational changes over time.

e. Evaluate reduction of erosional processes along the original study area shoreline.

This report presents results of the monitoring conducted from 1993 to 1994.

2 Descriptions of Study Area and Project

Study Area

The proximity of the refuge to Chesapeake Bay provides a considerable stabilizing effect on the climate of the refuge. The four seasons are well defined; however, temperature extremes are reduced. The Eastern Neck region, situated in the middle latitudes, has a humid, continental climate averaging 40.3 in of rainfall and 16.9 in of snowfall annually. August is usually the wettest month and February the driest. Thunderstorms occur on the average of 31 days per year. These storms normally cause little damage to buildings; however, they can cause extensive shoreline erosion. The growing season averages 232 days per year.

Prior to project construction, the Cabin Cove shoreline consisted of a narrow (1- to 6-m) sandy beach fronted by a narrow (1- to 2-m) intertidal zone. Shallow (<1 m), subtidal waters in front of the study area were extensive and several hundred meters wide. The tidal range in this portion of the Chester River was approximately 0.5 m. Salinity ranged from 7 to 12 parts per thousand (ppt). The substrate landward of the breakwaters was predominantly firm, laminar, mud clay with an admixture of sand, which varied in elevation between 0.3 m above and 1.2 m below mhw.

The narrow unvegetated beach graded up to a beach grass community dominated by American beach grass (*Ammophila breviligulata*), with lesser amounts of cocklebur (*Xanthium echinatum*), marsh elder (*Baccharis halimifolia*), and high tide bush (*Iva frutescens*). The beach was bisected at one point by a narrow (2-m) tidal gut fringed by common reed (*Phragmites australis*). The confluence of this gut with the Chester River was the most dynamic portion of study area shoreline. The configuration of the gut entrance changed weekly. Common reed also formed two other extensive stands. One stand occurred from the middle of the study area shoreline (above mhw) to the northern limit of the study area. The other stand occurred in the southern portion of the study area. Total area of common reed encompassed about 1,370 sq m.

The tidal gut was connected to a tidal pond occurring landward of the beach community. The pond was approximately 440 m by 220 m, and comprised about 70 percent of the habitat directly behind the study site. Shallow waters in the pond (<1 m) supported dense mixed beds of widgeon grass (*Ruppia maritima*) and redhead-grass (*Potamogeton perfoliatus*). Surrounding the pond was an estuarine, emergent wetland complex characterized by bulrush (*Scirpus robustus*), common threesquare (*Scirpus americanus*), smooth cordgrass, saltmeadow hay, and salt marshmallow (*Hibiscus moscheutos*). Behind this marsh was a band of deciduous forest that acted as a buffer between the wetland and agricultural fields on the refuge.

Project Description

Approximately 34,380 cu m of predominantly fine grained sand was hydraulically deposited landward of the five offshore breakwaters in June 1993. Material was deposited in three areas, designated Area A, Area B, and Area C (Figure 5). In order to assure tidal inundation to the tidal pond and associated estuarine emergent wetland complex, material was not placed in front of the tidal gut. Material was mounded to 0.304 m above mhw along the original shoreline in Areas A and C, allowed to dewater, and graded on a 1V:10H slope to mlw. Material deposited in Area B was mounded to 0.304 m above mhw along the breakwaters, and graded on a 1V:10H slope toward Area C. Areas A, B, and most of C are protected from the northwest fetch (severe winter storm fetch) by breakwaters or Geotubes. The lower (southern) fifth of Area C is exposed to the northwest fetch.

In addition to breakwaters, two Geotubes were deployed and filled with dredged material. Geotubes (Nicolon Corporation, Norcross, GA) are fabricated from geotextile fabric sewn into a tube. Pores in the fabric are sized to allow retention of hydraulically transported dredged material, and allow water drainage during tube filling. Geotubes are fitted with several filling portals that can be connected to a hydraulic pipeline. Each Geotube measured 0.9 m in diameter by 30.4 m long. After filling and settling, Geotubes had an elliptical cross section that provided 0.46 m effective height.

Planting began in July of 1993. The original plans called for plantings of smooth cordgrass in the intertidal zone, and saltmeadow hay on elevations above mhw. Inadequate availability of smooth cordgrass nursery stock (peat-pot grown) resulted in less of the intertidal zone being planted than designed. Several small experimental plots of smooth cordgrass sod were staked in the intertidal zone. Sod test mats were grown in a greenhouse in a coconut fiber material, and staked in the intertidal zone at the study area. Test mats did not have a well-developed root system, and were washed away by several summer storms during the first growing season. Most of the 11,000 smooth cordgrass sprigs were also lost by the first winter.

The 54,200 potted sprigs and 14,000 bare-root sprigs of saltmeadow hay

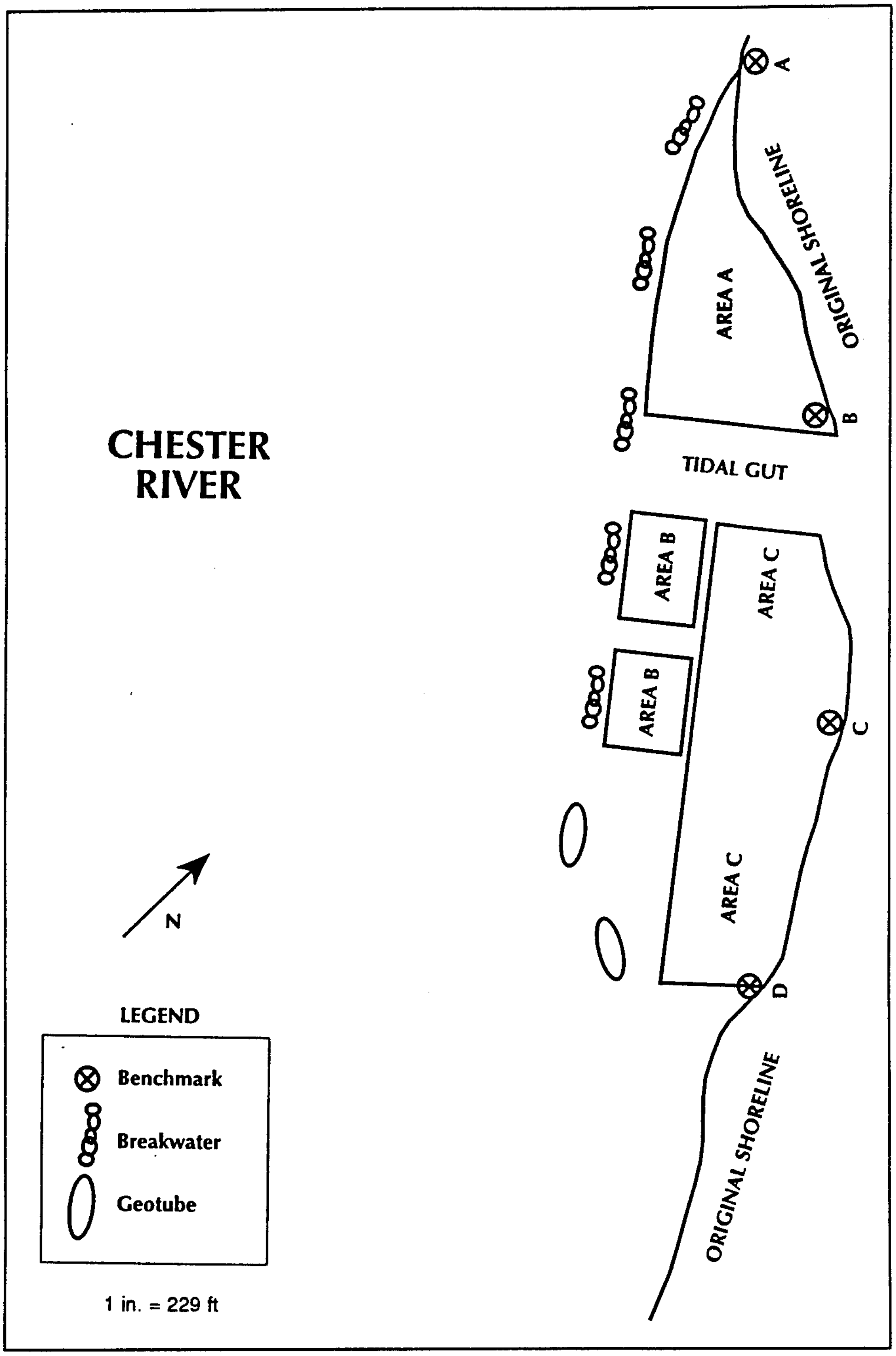

Figure 5. Dredged material deposition areas

were planted on 0.5-m centers above mhw throughout Areas A, B, and C. The southern fifth of Area C was not planted. Bare-root plants appeared dry and brown when delivered compared with the healthy, green potted plants. Prior to planting of the sprigs in 15.2-cm holes, each hole was treated with a small

amount of granular, slow-release fertilizer (Osmokote). By the end of the first growing season, 90 percent of the bare-root plant material had died. In contrast, potted plant survival was high.

During fall of 1993, the fringe of common reed was aerially sprayed with the systemic herbicide Rodeo. Although the herbicide successfully killed the plants, spraying was too late to prevent seed production. Areas planted in bare-root material that were devoid of vegetation the following spring were invaded by common reed through seed reproduction. This constituted approximately one-sixth of the study site. The majority of common reed colonizers were manually removed in the early summer of 1994 before extensive rhizome growth occurred. One confined common reed stand with a more developed rhizome system was not removed. This stand was sprayed the following fall. Immediately after common reed removal, barren areas were replanted with 10,000 potted sprigs of saltmeadow hay. Removal of Phragmites colonizers appeared successful through the remainder of the growing season.

In addition to saltmeadow hay plantings, 60.8 m of smooth cordgrass mat and 2,400 potted smooth cordgrass sprigs were planted in the intertidal zone during June of 1994. Mat material had a well-developed rhizome system, and was growing and expanding as of the fall of 1994. Smooth cordgrass sprigs did well along stable portions of the created shoreline, but were lost to erosion along more dynamic shoreline sections (vicinity of the tidal gut). Approximately one-fourth of these sprigs were lost. Throughout all tidal zones (high marsh and low marsh), natural colonization occurred, diversifying the planted community. By the close of the study period, 2.02 ha of wetland had been created, encompassing the remaining portions of Areas A, B, and C.

3 Methods

Monitoring data were collected along a series of 13 transects, oriented perpendicular to the shoreline (Figure 6). Transects were located to alternate between breakwater and open water. All transects except Transect 6 (representing the tidal creek) and Transects 12 and 13 (representing controls), were located to cross all vegetation zones in the planted wetland.

Transect lengths ranged from a minimum of 18 m at Transect 1 to a maximum of 108 m at Transect 9. Spacings of transects ranged from a minimum of 15 m between Transects 12 and 13 to a maximum of 68.4 m between Transects 11 and 12. Most transects were approximately 30.4 m apart.

Monitoring of the study site included biological and physical measurements collected from July 1993 through July 1994. Biological measurements included botanical and zoological sampling. Parameters measured were as follows:

a. *Botanical*

   (1) Stem density

   (2) Plant height

   (3) Invasion

   (4) Percent cover

b. *Zoological*

   (1) Sediment invertebrates

   (2) Fish and wildlife utilization

In addition to biological measurements, elevation changes to the dredged material due to sediment movement or erosion were measured yearly.

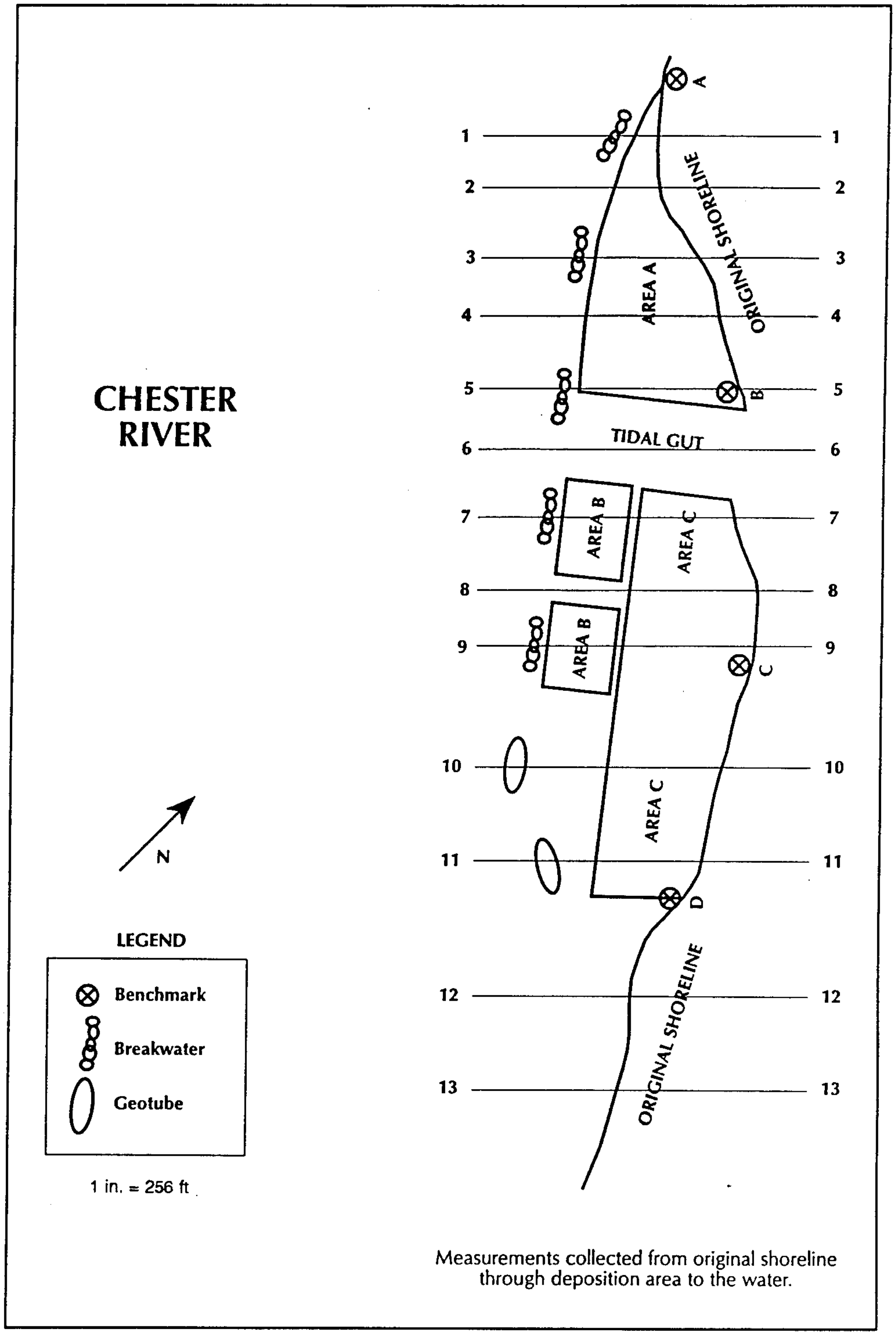

Figure 6. Monitoring transect locations

All botanical measurements were nondestructive and were conducted on a monthly basis for the first 6 months, after which the same measurements were conducted seasonally. Botanical measurements were conducted from a randomly placed 1-sq-m polyvinyl chloride (PVC) quadrat at 10-m intervals along

each transect (Hays, Summers, and Seitz 1981). Stem density was measured by counting all live stems within the quadrat (Brower, Zar, and von Ende 1990). Stem counts were tallied with the use of a hand-held mechanical counter. Plant height was measured by recording the heights of four randomly selected stems. Height recorded was from the tip of the highest aerial portion of the plant to the base of the plant at the sediment surface, and measured in centimeters (Pacific Estuarine Research Laboratory (PERL) 1990). Invasion was measured as number of invading plants (those species not planted), with percent cover visually estimated (Barry et al. 1978). Cover was measured seasonally by determining how much of the quadrat's surface was covered by foliage (Barry et al. 1978; Brower, Zar, and von Ende 1990).

Zoological measurements of sediment invertebrates were collected on a seasonal basis with the use of a bulb planter. Dimensions of the coring device were 11.5 cm by 5.7 cm. Sediment cores were taken from three habitat types: high marsh, low marsh, and shallow water.

A total of three cores from each habitat type were collected from randomly selected transects during each sampling period. As part of an unrelated study, sediment cores were also obtained from a pristine salt marsh located on Bombay Hook National Wildlife Refuge, Delaware, and used for qualitative comparative measures. After collection, sediment cores were individually sieved through a 0.5-mm-mesh sieve bucket (Wildco, Saginaw, MI). Invertebrates retained in the bucket were transferred to a 5 percent formalin solution for preservation. Preserved samples were sent to Cove Corporation (Lusby, MD) for identification to the lowest taxon possible.

Wildlife utilization was recorded monthly for the first 6 months of the study, and seasonally for the next 6 months. All wildlife observations were conducted before other sampling methods were employed for that particular sampling period. Wildlife utilization was determined by actual sightings, tracks, spoor, nests, and sounds. Observations of live animals were conducted within a 9-m zone on either side of each transect. Species, number observed, type of observation, date, and location were recorded. In addition to wildlife utilization, several qualitative fish collections were made using a 7.5-m beach seine.

Physical measurements involved surveying the study site to document changes in beach/wetland morphology due to dredged material settling or wind- and wave-induced movement. Elevations relative to mean low low water (mllw), based on Corps data, were measured along each transect with a Sokkia C3A surveying transit and stadia rod. A Corps benchmark near Transect 1 was used to establish three additional benchmarks (Figure 6) from which to establish elevations along the other transects (Brinker and Minnick 1987). Benchmarks and their associated transects are shown in the following tabulation.

Benchmark	Transect No.
A	1,2
B	3,4,5,6,7
C	8,9,10,11
D	12,13

Measurements were collected every 2 m until reaching either a breakwater or open water between breakwaters. Elevation calculations were based on the following formula:

$$E = (T - R) + BM$$

where

E = elevation

T = height of transit above benchmark

R = rod height

BM = benchmark elevation

Elevations were measured at the time of initial planting and 12 months later. Initial and final elevations were graphed and compared for determining changes in dredged material topography.

4 Results

Beach Profile Changes

Dredged material beach profiles are presented in Appendix A. Elevations were taken in the summer of 1993 immediately after dredged material placement, and again in the summer of 1994. Measurements are presented by transect. Benchmark D was lost to erosion during the winters of 1993 and 1994; therefore, profiles are missing for Transects 12 and 13. Data are lacking for Transect 9.

Prior to dredged material placement, the study area shoreline profile consisted of a narrow (1- to 6-m) sandy beach fronted by a narrow (1- to 2-m) and steep (1V:2H slope) intertidal zone. Initial dredged material placement changed this profile to a wide beach (18-90 m) and a wider (10- to 15-m), more gradually sloping (1V:10H) intertidal zone. The new shoreline was oriented parallel to the old shoreline.

Wave action repositioned the material within the first 2 weeks after placement. Area B (Figure 6), which had sloped from above mhw at the breakwaters toward land, reformed into points sloping from land toward the river (Figure 7). As the summer progressed, former areas of created straight shoreline between breakwaters receded landward to form coves. By the end of the study period, beach width had increased toward the midpoint of the breakwaters and Geotubes, and decreased in areas between breakwaters and tubes (Figure 7). In the short term, it appeared this tombolo formation had reached an equilibrium planform throughout much of the study site. In addition, an apparently stable and much wider, as compared to preconstruction conditions, intertidal zone existed.

Unstable shoreline conditions were observed throughout the study period at Transects 5, 6, and 7 in the area of the tidal gut. Prior to dredged material placement, this area exhibited dynamic shoreline conditions, with strong ebb tide flows exiting the gut. These conditions persisted during the study period, and caused dredged material losses on the gut side of Areas A and C.

The appearance of the exposed original shoreline in the vicinity of Transects 12 and 13 suggests erosion is continuing. At the time of submission

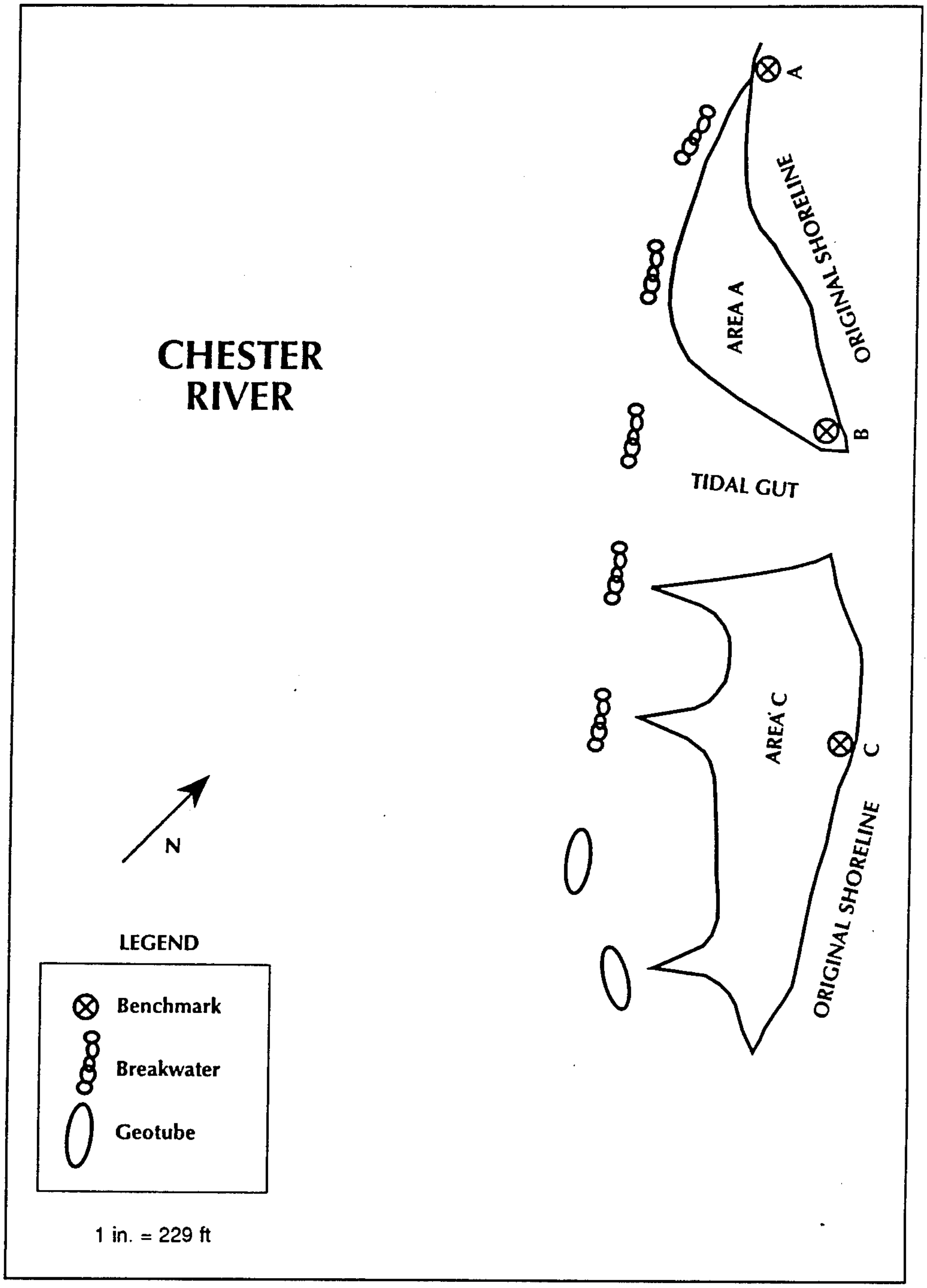

Figure 7. 1994 shoreline configuration

of this report, all other original shoreline sections within the study area were stable.

Geotubes

Geotubes were located at the channelward end of Transects 10 and 11.

Each tube had an effective height off the bottom of 0.46 m. The top of the tube at Transect 10 was 0.15 m below mllw. The top of the tube at Transect 11 was slightly above mllw.

Transect 10 tube was always underwater, and dissipation of wave energy did not appear as effective as the tube at Transect 11. During low tide a tombolo point was evident at Transect 11, but not at Transect 10.

The winter of 1994 was one of the worst on Chesapeake Bay in the past decade. The upper bay, including the Chester River in front of the study area, froze shoreline to shoreline. Ice piled up 3.6 m high on top of the stone breakwaters. No damage or Geotube movement was observed the following spring.

A fouling community composed of filamentous algae and barnacles colonized both tubes during the first growing season. Ice removed all growth during the winter; however, by the end of the study period both tubes were covered by algae and supported low numbers of barnacles (several every meter).

Vegetation Analysis

A seasonal habitat analysis was conducted by transect. The following habitat categories were included:

a. Shallow water unvegetated (SWU)

b. Shallow water vegetated (SWV)

c. Unvegetated beach (UB)

d. Low marsh-smooth cordgrass zone (LM)

e. High marsh-saltmeadow hay zone (HM)

f. Phragmites (P)

Percent habitats for 1993 and 1994 are presented in Appendix B. Table 3 summarizes habitat frequency of occurrence percentages given in Appendix B during midsummer 1994, with SWU (42.8 percent), UB (36.1 percent), and HM (18.5 percent) the dominant habitat categories. Late season growth after data collection was completed filled in some of the UB category, and is not reflected by the data. In addition, the UB category included the intertidal zone when sampling occurred at low tide, and therefore percentages given are inflated. The SWU category includes both intertidal and shallow subtidal zones.

Sampling indicated that stem density and stem height at the site did not

compare favorably with the control site (Figures 8 and 9). Given the short amount of time the site had to develop (1.5 growing seasons), this was not surprising. In addition, the control site used was a Delaware marsh complex where data existed from an unrelated study. Because the data were available, they were included for qualitative comparison. Tidal range within the control site was significantly higher than the study site: 1.2 m and 0.5 m, respectively.

Percent cover data (Figure 10) compared more favorably with the control site: 55-65 percent compared to 100 percent at the control site. Percent cover values increased from 1993 to 1994.

Wetland sod mats staked along the mhw line in the vicinity of Transects 7 and 8 during the summer of 1994 were not sampled separately, and the data do not represent sod growth and vigor. Seed production was good, and sod mats appeared healthy. Rhizome growth had extended beyond the mats, and attached securely into underlying dredged material substrate. Sandy sediment from onsite or offsite sources had covered the formerly exposed edges of the matting, lessening the chance of undermining from wave scour.

Seed production and plant growth for both species throughout the site visually appeared good. This was not represented by the stem height and density data. The number of quadrat hits on sparsely vegetated portions of the site and hits on former beach areas lost to erosion explains the low 1994 values.

Smooth cordgrass planted along dynamic shoreline sections adjacent to the tidal gut were lost to erosion within the first week after planting. Approximately 25 percent of the original 2,400 sprigs were lost. Saltmeadow hay planted in summer of 1993 between Transects 7, 8, and 9 had acquired a natural, filled-in appearance. The remainder of the saltmeadow hay areas had not filled in between the original 0.5-m spacing; however, plants appeared healthy. Most of these were planted the summer of 1994.

Figure 11 depicts the number of plant species observed during the course of the study period. At the beginning the site was rapidly colonized by sea rocket (*Cakile edunata*) and common reed. During the first summer, all common reed invasion was by rhizome extension. During sampling, all rhizome growth encountered was severed from the supporting Phragmites stands. Common reed was a problem the second summer (after herbicide treatment) due to viable seed dispersal. By the end of the second summer the site supported 16 wetland and dune species (Table 4). By frequency of occurrence common reed constituted 1.5 percent, and was treated with herbicide again.

Shallow subtidal waters around Transect 1 were colonized by widgeon grass. The bed was very sparse, and became established in an area completely protected from wave energy.

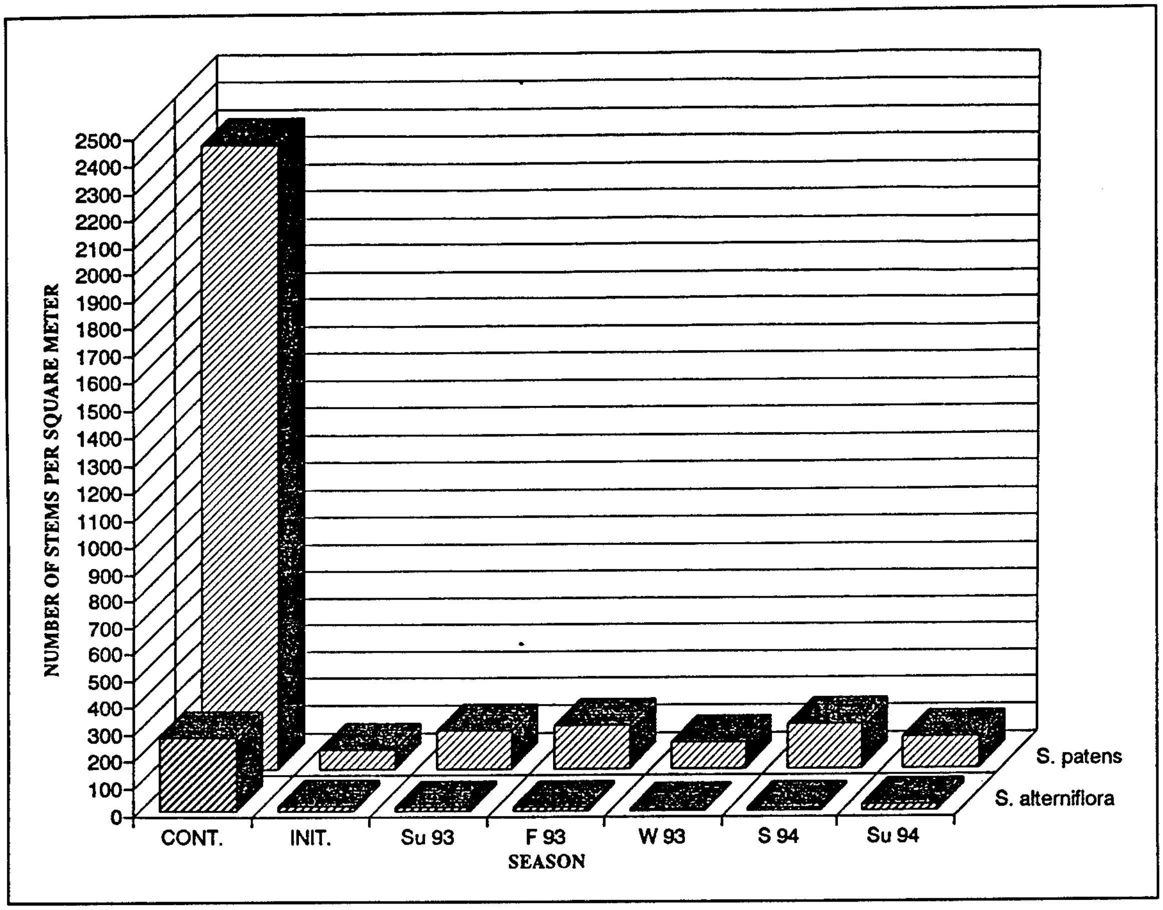

Figure 8. Mean stem density of planted grasses in 1993-1994

Fish and Wildlife Utilization

Avian species were the primary user group at the study site. Nineteen species of birds were documented using the created wetland, tidal flats, shallow waters, and breakwaters for feeding and loafing. Canada geese and Forster's terns (*Sterna forsteri*) were the most frequently observed species (Table 5). A list of bird species relative to the location they were observed is presented in Table 6. Ms. Dolly Minis and Ms. Meg Cowenhoven, two volunteer birders, performed a bird survey along the shoreline fronting the refuge headquarters, not far from the study site. Table 7 presents their data covering September 1993 to May 1994.

Three weeks after dredged material placement, 12 diamondback terrapin (*Malaclemys terrapin*) nests were located on the higher elevations of the created beach. The only other reptilian species documented was northern watersnake (*Natrix sipedon*).

Fish collections were qualitative, and number of fish collected were not recorded. Beach seines taken between Transects 6 and 10 collected

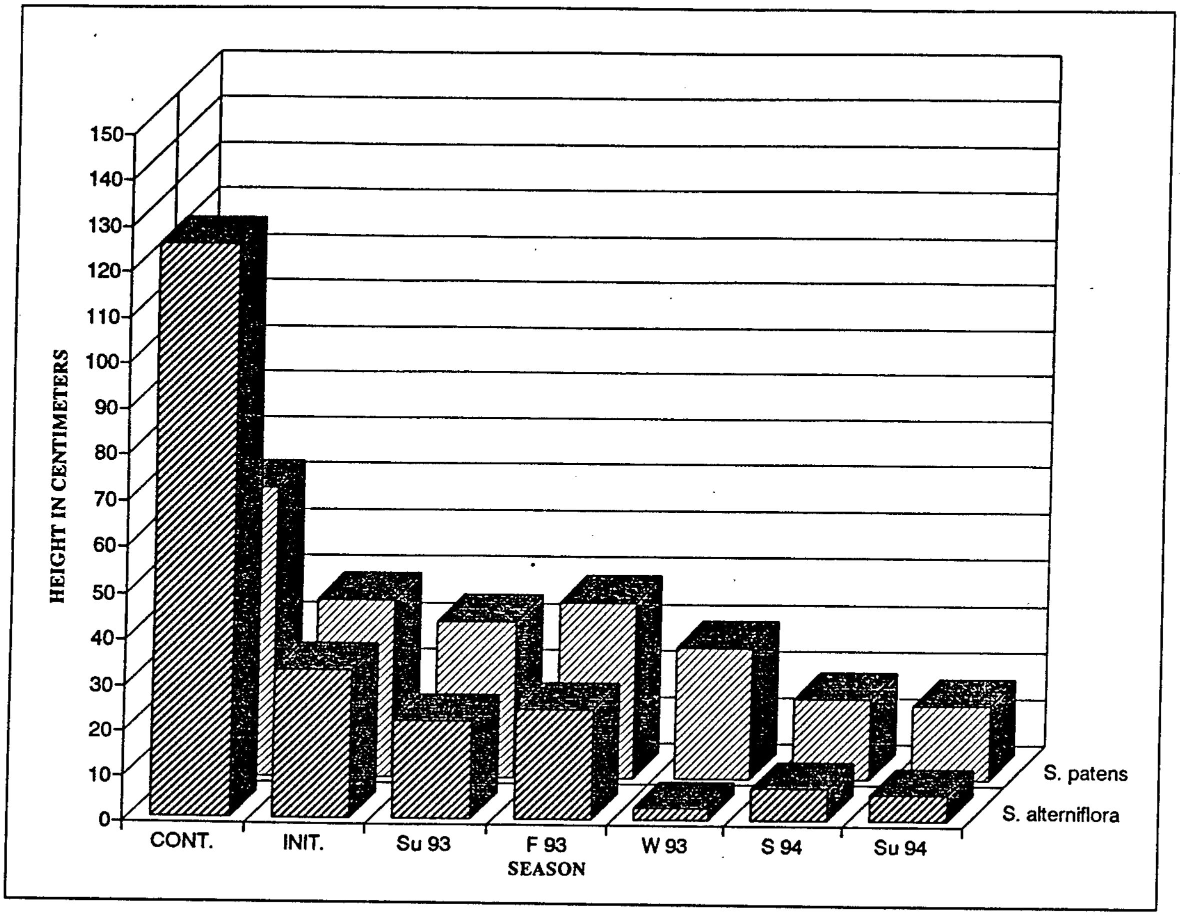

Figure 9. Mean stem height of planted grasses in 1993-1994

13 estuarine species. Notable game species collected included striped bass (*Morone saxatilis*), white perch (*Morone americana*), and Atlantic croaker (*Micropogonias undulatus*). Table 8 lists reptile and fish species observed or collected.

Five species of mammals were documented using the study site. White-tailed deer (*Odocoileus virginianus*) was the most frequently documented species. Table 9 lists mammal observations by location.

Sediment Invertebrate Analysis

Seventeen species of invertebrates, representing 10 orders, were collected at the study site. Habitats sampled were high marsh, low marsh, and shallow water. Annelida and Crustacea were the dominant orders present. Species and numbers of invertebrates collected are presented in Table 10.

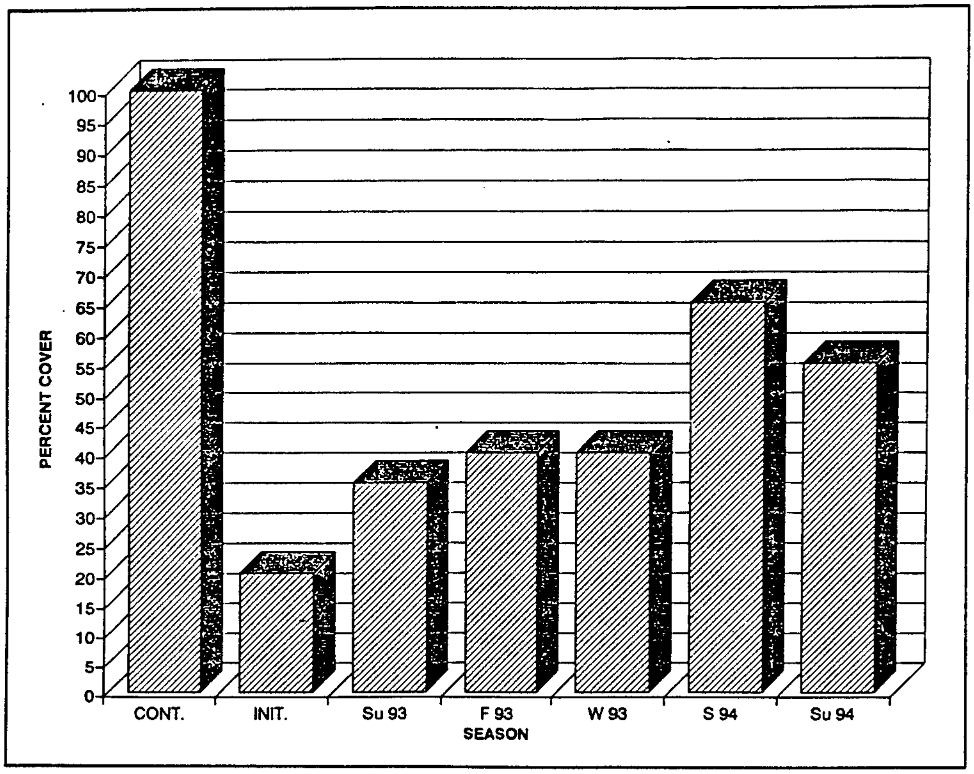

Figure 10. Percent cover of vegetational quadrats in 1993-1994

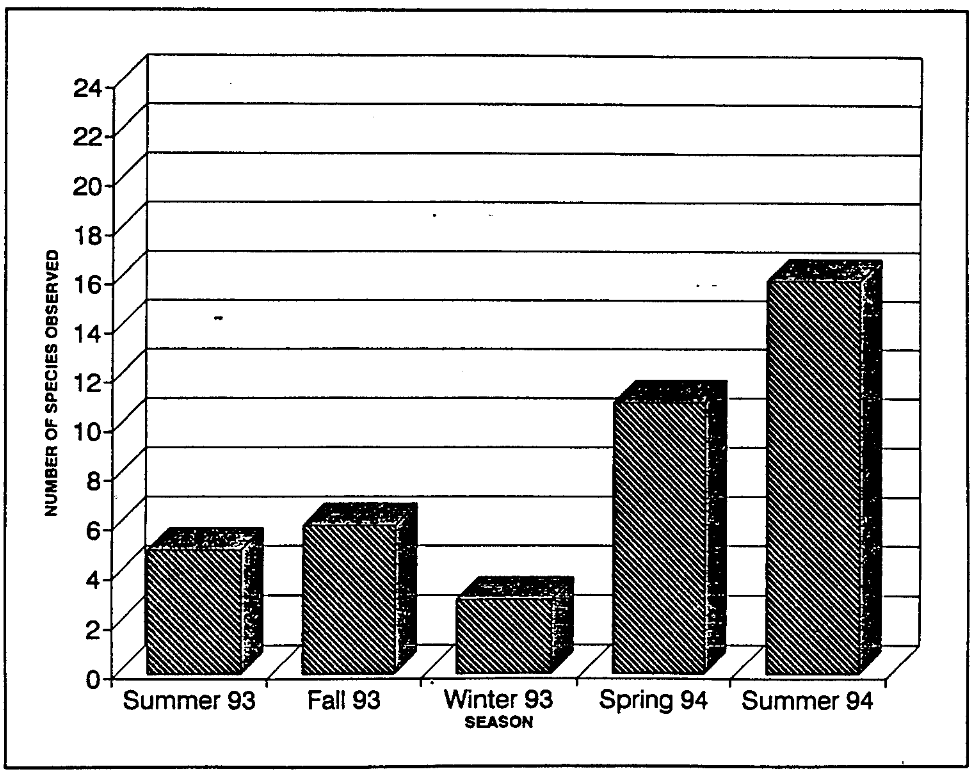

Figure 11. Number of plant species observed in wetland creation study site

5 Discussion

Conclusions and Recommendations

Planting smooth cordgrass and saltmeadow hay in 1993 began immediately after dredged material placement. As previously discussed, dredged material was quickly (in the first 2 weeks) repositioned by wave action into tombolo points and scalloped coves. Wherever coves were formed, plant material was lost. Future projects should allow for dredged material repositioning and the formation of a fairly stable shoreline configuration before planting occurs.

As witnessed in areas adjacent to the tidal gut, shorelines do not always stabilize, even within the wave shadow of breakwaters. It would have minimized dredged material losses if deposition had not occurred within the range of tidal gut/channel movement. Geotubes could have been placed parallel to the gut shoreline to stabilize channel movement, although predicting channel movement regarding where to place the tubes would be difficult.

Plantings alone would most likely not have been adequate to stabilize the dredged material. Fine-grained, sandy dredged material will require structural, as well as nonstructural (plants), protection when used in the harsher Chesapeake Bay and large tributary wave climates. The original shoreline along Areas A and C where structural protection was provided remained stable.

High marsh zones in Areas A, B, and C that remained after the first growing season remained relatively stable. Sprigged low marsh zones were less stable. Up to 25 percent of potted smooth cordgrass sprigs were removed by wave action days after planting. Workers planting smooth cordgrass noted that waves would often immediately resuspend sediment used in filling the planting holes, leaving peat pots exposed. Smooth cordgrass sprigs did best at the upper elevations of the low marsh zones and in those areas more protected by wave action.

The established smooth cordgrass sod mats planted and staked the summer of 1994 appeared to weather wave energy much better than individual sprigs. Future projects could incorporate cordgrass mats as a first line of defense against erosional forces. Sprigged cordgrass planted behind such a defensive line might then have time to develop an anchoring root system. To the extent

dredging time of year restrictions allow, planting all species earlier in the spring or summer would allow for a more developed root system before harsh winter weather arrives. Without plantings, natural colonization would not have occurred quickly or densely enough to stabilize the site during the study period.

Common reed invasion will continue to be a problem without continuing spot control. Dredging scheduling did not allow common reed to be controlled before site development, which would have been preferable. Common reed colonization by seed dispersal was possible due to seed formation occurring before the first treatment.

Geotubes withstood an extremely harsh Chesapeake Bay winter, and did support a fouling community. Erosion protection would have been improved if the tubes were sized and deployed in shallow enough waters so that the effective cross-sectional height of the tube was at least 0.5 m greater than most tide and wave elevations. Based on short-term observations, Geotubes appear to be a cost-effective alternative to riprap breakwaters. Questions remain as to their expected life span relative to ultraviolet radiation deterioration and susceptibility to vandalism.

Created habitats were used by 19 species of birds, 2 species of reptile (including nesting terrapins), and 5 species of mammal. Much of the habitat use was by shorebirds taking advantage of the increased area of tidal flats. Wetland habitats were used primarily by nesting terrapins and avian and mammalian hunters. Twelve species of fish were collected in the shallow waters within the study site. These species would have been expected prior to project construction. However, it is likely the substrate and associated fouling communities provided by stone breakwaters and Geotubes increased the site's fish habitat value. If the sparse widgeon grass bed expands, a more diverse fishery habitat will be available. Low marsh zones were not included in the qualitative fish sampling effort.

Meeting Project Objectives

Project Objective 1 was to provide an environmentally preferable alternative to unconfined, overboard dredged material disposal. Approximately 75-80 percent of this objective was met, in that 75-80 percent of the material stayed onsite. Material lost to erosion was carried by prevailing drift currents, most probably acereting along downdrift shorelines and settling over a large subtidal area.

Project Objective 2 was to stop or minimize erosional losses of ecologically important habitats. The existing marsh habitat landward of the study site was the ecologically important habitat the project was attempting to protect. Along most of Areas A and C the objective was met. The southern end of Area C exposed to the northwest fetch did exhibit some erosion, approximately 5 percent of the targeted shoreline.

Project Objective 3 was to create wetland habitat. Both vegetated and nonvegetated wetland habitats were created and used by listed fish and wildlife species; therefore the objective was met. Monitoring did not attempt to compare the habitat value of the created wetland to a natural wetland, and no conclusion can be drawn in that regard.

Given the limited duration and scope of the monitoring study, expectations were to answer simple questions regarding potential for expanded application of beneficial uses of dredged material and improving the technique. Modifications to the erosion control design used on the Eastern Neck project should lead to improved dredged material stability after placement. Likewise, changes in planting times, plant materials, planting methods, and common reed control can improve wetland habitat development. Only longer term studies, aimed at the wide array of wetland values, can answer questions about full, functional wetland restoration.

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Table 1
Eastern Shore Island Losses in the Middle Portion of Chesapeake Bay (From Historic and Recent National Ocean Survey Chart Data)

	Historic Acreage		Recent Acreage		
Island	**Year**	**Acres**	**Year**	**Acres**	**Erosion, acres**
Barren	1664	700	1989	250	-450
Bloodsworth Series	1849	6,051.7	1942	5,243.3	-808.4
Bodkin	1742	1,286	1990	0.9	-1,285.1
Cockey's[1]	1846	5.7	1990	0	-5.7
Cows[1]	1901	6.2	1990	0	-6.2
Deal	1849	2,168.1	1942	1,882.5	-285.6
Deep Banks	1849	31.9	1942	4.6	-27.3
Eastern Neck	1846	2,435.9	1942	2,001.8	-434.1
Great Marsh[1]	1846	6.4	1990	0	-6.4
Hambleton[1]	1775	85	1990	0	-85
Herring[1]	?	?	1990	0	?
Hog	1854	38.3	1942	27.5	-10.8
Holland	1843	253	1980	140	-113
Hooper Series	1848	3,928.1	1942	3,085.4	-842.7
James	1664	1,350	1990	269	-1,081
Johnson	1854	57.4	1942	22.9	-34.5
Kent	1848	21,094.8	1942	19,302.1	-1,792.7
Little	1854	19.1	1942	6.4	-12.7
Little Deal	1849	357.1	1942	257.1	-100
Long[1]	?	?	1990	0	?
Long Marsh	1854	31.9	1942	18.3	-13.6
Parson	1854	172.2	1942	128.5	-43.7
Philpots	1899	25.5	1942	8.3	-17.2
Poplar Series	1846	752.5	1942	238.8	-513.7
Powell[1]	1755	55	1990	0	-55
Punch[1]	1848	1.3	1990	0	-1.3
Royston[1]	1755	41	1990	0	-41

Note: Source: Dave Gelenter. (1990). "Eastern shore island losses," Unpublished report prepared by University of Maryland's Center for Global Change, Laurel, MD, for the U.S. Fish and Wildlife Service, Chesapeake Bay Field Office, Annapolis, MD, Project Manager, John W. Gill.
[1] Erosion resulted in entire island being lost.

(Continued)

Table 1 (Concluded)

Island	Historic Acreage		Recent Acreage		Erosion, acres
	Year	Acres	Year	Acres	
Sharps[2]	1812	631	1990	0 (at high tide)	-631
Sherwood[1]	1755	41	1990	0	-41
South Marsh	1849	3,590.2	1942	2,910.9	-679.3
Swan[1]	1848	6.4	1990	0	-6.4
Taylors	1848	7,894.6	1942	7,621.7	-272.9
Tilghman	1847	2,015	1983	1,262	-753
Turtle Egg[1]	1849	15.9	1990	0	-15.9
Wrotten	1901	505.1	1942	433.6	-71.5
Totals 35 (12 islands lost)	55,653.3		45,115.6		-10,537.7
The following islands are former points that were cut off the mainland by water. The specific date of separation is unknown, but occurred sometime after 1848.					
Hills Point	1848	Attached	1942	36.7	
Ragged	1848	Attached	1942	128.6	

[1] Erosion resulted in entire island being lost.
[2] Seen at low tide.

Table 2
1993 Maryland Colonial Waterbird Population Estimates

Species	Censused Colonies	Active Colonies	Number of Breeding Pairs Per Colony (Median)[1]	Number of Breeding Pairs Per Colony (Range)[1]	Statewide Population (Number of Censused Breeding Pairs)[2]	Statewide Population (Estimated Number of Breeding Pairs)[3]
Brown Pelican	1	1	17	n/a	17	17
Double-crested Cormorant	3	3	28	2-302	332	332
Great Blue Heron	26	47	21	1-1,632	1,632	4,372
Great Egret	11	16	15	4-248	778	1,012
Snowy Egret	6	8	200	2-982	2,297	2,336
Cattle Egret	4	8	579	211-971	2,340	2,347
Little Blue Heron	4	8	56	2-151	264	322
Tricolored Heron	4	8	66	4-549	744	803
Black-crowned Night Heron	6	15	15	1-63	137	470
Yellow-crowned Night Heron	3	13	11	2-17	32	52
Glossy Ibis	4	8	216	1-979	1,427	1,442
Great Black-backed Gull	9	22	2	1-8	21	167
Herring Gull	1	25	6	3-20	92	3,152
Royal Tern	11	1	350	n/a	350	350
Common Tern	17	17	24	1-452	1,328	1,328
Forster's Tern	12	12	27	13-511	1,099	1,099

Note: Source: Dave Brinker, Maryland Department of Natural Resources, Wildlife Division, Annapolis, MD.
[1] Median and range calculated from those colonies in which counts of nests were obtained.
[2] Population estimates derived from 1993 field data. Not included are active colonies not censused.
[3] Population estimates based upon all known active colonies. For active colonies not censused, estimates derived from past censuses, primarily those of 1992.

(Continued)

Table 2 (Concluded)

Species	Censused Colonies	Active Colonies	Number of Breeding Pairs Per Colony (Median)[1]	Number of Breeding Pairs Per Colony (Range)[1]	Statewide Population (Number of Censused Breeding Pairs)[2]	Statewide Population (Estimated Number of Breeding Pairs)[3]
Least Tern	12	14	8	1-102	240	240
Gull-billed Tern	1	1	1	n/a	1	1
Black Skimmer	4	4	14	5-187	270	270

Table 3
Midsummer 1994 Habitat Category Percent Frequency of Occurrence

Transect	Frequency of Occurrence for Habitat Category, percent					
	SWU	SWV	UB	LM	HM	P
1	0	0	91.7	8.3	0	0
2	80.5	0	16	0	0	3.6
3	0	0	89.3	0	2	8.7
4	47.7	0	28.5	0	20.3	3.5
5	8	0	71.6	0	20.4	0
6	66	0	33.9	0.1	0	0
7	55.4	0	30.9	0	13.7	1
8	47.0	0	17.3	0	35.8	0
9	49.5	0.3	5.6	1.9	42.7	0
10	55.8	0	2.5	0	41.7	0
11	61.2	0	10	0	28.8	0
Mean	42.8	0.03	36.1	0.9	18.5	1.5

Note:
SWU = Shallow water unvegetated
SMV = Shallow water vegetated
UB = Unvegetated beach
LM = Low marsh
HM = High marsh
P = Phragmites

Table 4
List of Naturally Occurring Plant Species Observed in 1993-1994 (Observations Are Based on Transect and Non-Transect Observations)

Common Name	Scientific Name	Date	Transect No.
Broadleaf			
Orache	*Atriplex patula*	06-01-94 07-19-94	3, 4, 5, 8, 10, 11 4, 6
Smartweed	*Polygonum sp.*	06-01-94	4
Pokeweed	*Phytolacca americana*	07-19-94	3
Evening primrose	*Onethera biennis*	08-10-94	4
Seaside goldenrod	*Solidago sempivirens*	06-01-94 07-19-94	5 9
Saltmarsh fleabane	*Pluchea purpurascens*	07-19-94	3, 4, 9
Curly dock	*Rumex crispus*	07-19-94	4
Cocklebur	*Xanthium echinatum*	07-19-94	9, 10
Waterhemp	*Acnida cannabinus*	06-01-94 07-19-94	4, 5 5, 7, 9
Sea rocket	*Cakile edunata*	08-30-93 10-13-93 06-01-94 07-19-94	11 11 4, 8, 11 7, 10, 11
Narrowleaf			
Smooth cordgrass	*Spartina alterniflora*	08-30-93 12-08-93	11 11
Saltmeadow hay	*Spartina patens*	09-09-93	13
Saltgrass	*Distichilis spicata*	11-12-94	4
American beach grass	*Ammophila breviligulata*	06-01-94	9
Common reed	*Phragmites communis*	07-26-93 08-04-93 08-11-93 08-19-93 08-30-93 09-09-93 10-13-93 11-12-93 12-08-93 02-02-94 02-25-94 06-01-94	1, 2, 3, 4, 5, 7, 8, 12 1, 3, 4, 5, 7, 8, 12, 13 All except 6 & 10 All except 6, 8, & 9 All except 6 & 10 All except 6 All except 6, 9, & 10 All except 6, 9, & 10 All except 6 & 10 2, 3, 4, 5, 7, 8, 12, 13 1, 4, 5, 7, 8, 9, 13 3, 4, 5, 7, 8, 11, 12, 13
Bulrush	*Scirpus robustus*	08-30-93 09-09-93 11-12-93	12 12, 13 12

(Continued)

Table 4 (Concluded)

Common Name	Scientific Name	Date	Transect No.
Bulrush (Con't)	*Scirpus robustus*	02-02-94	12
Succulents			
Glasswort	*Salicornia europaea*	07-19-94	1
Shrubs			
Marsh elder	*Iva frutescens*	06-01-94 07-19-94	4, 5, 8, 9 8
Groundsel tree	*Baccharis halimifolia*	06-01-94	4
Swamp rose	*Rosa palustris*	06-01-94 07-19-94	8 8
Marshmallow	*Hibiscus Moscheutos*	09-09-93	4
Red maple	*Acer rubrum*	06-01-94 07-19-94	4 5
Submerged Aquatic Vegetation			
Widgeon grass	*Ruppia maritima*	06-01-94 07-19-94	1 1
Horned pondweed	*Zannichellia palustris*	11-12-93	1

Table 5
Frequency and Percent of Bird Species Observed at Wetland Creation Site, July 1993-July 1994

Species	Frequency	Relative Species Density
Kingbird	1	0.20
Redwing blackbird	2	0.40
Fish crow	2	0.40
Sanderling	2	0.40
Tundra swan	3	0.60
Royal tern	4	0.80
Killdeer	4	0.80
Great blue heron	4	0.80
Osprey	4	0.80
Snowy egret	4	0.80
Bonaparte's gull	6	1.20
Laughing gull	9	1.80
Common tern	10	2.00
Least tern	13	2.61
Herring gull	27	5.41
Mute swan	28	5.61
Ring-billed gull	47	9.42
Forster's tern	129	25.85
Canada goose	200	40.08
Total	499	100

Table 6
List of Bird Species Relative to the Location They Were Observed

Common Name	Scientific Name	No.	Date	Location
Redwing blackbird	*Agelaius phoeniceus*	2	7-1-93	Transect 8 on Phragmites stems
Fish crow	*Corvus ossifragus*	2	7-1-93	Breakwater 3
Kingbird	*Tyrannus tyrannus*	1	7-1-93	Hovering over transect 8
Snowy egret	*Egretta thula*	1	8-4-93	Breakwater 4
Ring-billed gull	*Larus delawarensis*	8	8-4-93	Breakwater 4
Forster's tern	*Sterna forsteri*	5	8-4-93	Breakwater 4
Osprey	*Pandion haliaetus*	1	8-4-93	Flying over transect 7
Bonaparte's gull	*Larius philadelphia*	6	8-4-93	Sand flat in front of breakwater 4
Ring-billed gull	*Larus delawarensis*	13	8-4-93	Breakwater 5
Forster's tern	*Sterna forsteri*	20	8-4-93	Breakwater 5
Common tern	*Sterna hirundo*	10	8-4-93	Breakwater 5
Forster's tern	*Sterna forsteri*	25	8-11-93	Breakwater 1
Ring-billed gull	*Larus delawarensis*	15	8-11-93	Breakwater 1
Killdeer	*Charadrius vociferus*	1	8-11-93	Transect 8 shoreline
Forster's tern	*Sterna forsteri*	19	8-19-93	Breakwater 5
		23	8-19-93	Breakwater 3
		1	8-19-93	Breakwater 2
Ring-billed gull	*Larus delawarensis*	1	8-19-93	Breakwater 5
		5	8-19-93	Breakwater 3
		2	8-19-93	Breakwater 2
Snowy egret	*Egretta thula*	2	8-19-93	Mudflat in front of breakwater 1
Royal tern	*Stern maxima*	4	8-30-93	Breakwater 2
Ring-billed gull	*Larus delawarensis*	3	8-30-93	Breakwater 2
Forster's tern	*Sterna forsteri*	53	8-30-93	Breakwater 2
Solitary sandpiper	*Tringa solitaria*	3	8-30-93	Sand flat in front of breakwater 2

(Continued)

Table 6 (Concluded)

Common Name	Scientific Name	No.	Date	Location
Snowy egret	*Egretta thula*	1	11-12-93	Sand flat in front of breakwater 3
Ring-billed gull	*Larus delawarensis*	2	11-12-93	Shallows between breakwater 3-2; shallows behind transect 11 tube
Herring gull	*Larus argentatus*	1	11-12-93	Shallows between breakwater 2 & 3
Sanderling	*Calidris alba*	2	11-12-93	Shallows between breakwater 2 & 3
Killdeer	*Charadrius vociferus*	3	11-12-93	Shallows in front of breakwater 2
Mute swan	*Cygnus olor*	15	12-8-93	Flying over entire study site
Canada goose	*Branta canadensis*	200	12-8-93	Flying over break-waters 15
Ring-billed gull	*Larus delawarensis*	3	2-25-94	Transect 10 shoreline
Tundra swan	*Cygnus columbianus*	1	2-25-93	Flying over break-waters 5-1
Osprey	*Pandion haliaetus*	1	6-1-94	Nesting platform near transect 9
Mute swan	*Cygnus olor*	2	6-10-94	Transects 3 & 5
Great blue heron	*Ardea herodias*	4	7-19-94	Transect 1 shallows
Osprey	*Pandion haliaetus*	2	7-19-94	Transect 9 nest platform
Ring-billed gull	*Larus delawarensis*	2	7-19-94	Breakwater 4
Herring gull	*Larus argentatus*	26	7-19-94	Breakwater 4
Laughing gull	*Larus atricilla*	9	7-19-94	Breakwater 4
Least tern	*Sterna albifrons antillarum*	13	7-19-94	Breakwater 4
Forster's tern	*Sterna fosteri*	7	7-19-94	Breakwater 4
Tundra swan	*Cygnus columbianus*	2	7-19-94	Flying over transect 10-1
Mute swan	*Cygnus olor*	11	7-19-94	Flying over transect 10-1

Table 7
Bird Bulkhead Survey, 1993-1994

Species	9/29	10/5	10/13	10/19	10/21[1]	11/8	11/12[2]	11/19	11/24,29	12/8	12/17	1/2	1/30	2/17[3]	3/17[4]	3/23	3/30	4/23	5/1
Loon, Common						1				1									
Red Necked Grebe								10											
Horned Grebe																	6		
D.C. Cormorant	1	1		2															
Canada Goose					200	81			XXX	XXXX		XXXX	25						
Mallard								2											
Black Duck						30		37	23	71	26	6							
Scaup Sp.													300						
Goldeneye										1							11		
Bufflehead						37		14	30	5	42	4	10		1	8	37 +	4	
White W. Scoter																	6	1	
Red Br. Merganser											20					26	1		
Common Merganser		1						3							2 Sp.				
Mute Swan		23	3	2															
Osprey				1															
Great Blue Heron	2	3	3	3				1		1									
Great Egret	4			1															
Snow Egret		1																	

(Continued)

Note: X = Thousand
1 October 21 - Surveyed areas 2A and 2B only.
2 November 12 - Surveyed area 3 only.
3 February 17 - Frozen solid, no birds.
4 March 17 - Mostly frozen.
5 Many, but not counted.

Table 7 (Concluded)

Species	9/29	10/5	10/13	10/19	10/21[1]	11/8	11/12[2]	11/19	11/24,29	12/8	12/17	1/2	1/30	2/17[3]	3/17[4]	3/23	3/30	4/23	5/1
Killdeer						1													1
Yellowlegs Sp.							1												
Spotted Sandpiper			2																
Herring Gull	25	11	10	9	50	2			--[5]						1 Sp.				
Ring-Billed Gull	25	3	4	4	1	14		1			1					3			
Great Black-Backed Gull		1		2															
Laughing Gull			1																
Caspian Tern	4	7																	
Belted Kingfisher			3	3		3		4	2	2	1					3	2	2	

Table 8
List of Reptile and Fish Species Observed in 1993-1994

Common Name	Scientific Name	Number of Sightings	Date	Transect No.
		Reptiles		
Northern watersnake	*Natrix sipedon*	1	6-1-94	6
		1	6-10-94	6
Diamondbacked terrapin	*Malaclemys terrapin*	12[a]	7-14-93	8-10
		1	6-10-94	5
		Fish[b]		
Norfolk spot	*Leiostomus axanthurus*		8-10-94	6-9
Atlantic croaker	*Micropogonias undulatus*		8-10-94	6-9
Striped bass	*Morone saxatilis*		8-11-93	6-10
			8-10-94	6-9
White perch	*Morone americana*		8-11-93	6-10
			8-10-94	6-9
Menhaden	*Brevoortia tyrannus*		8-10-94	6-9
Alewife	*Alosa pseudoharengus*		8-10-94	6-9
Gizzard shad	*Dorosoma cepedianum*		8-10-94	6-9
Atlantic needlefish	*Strongylura marina*		8-10-94	6-8
Hogchoker	*Trinectes maculatus*		8-11-93	9-10
Striped killifish	*Fundulus majalis*		8-11-93	6-10
			8-10-94	6-9
Mummichog	*Fundulus heteroclitus*		8-11-93	6-10
			8-10-94	6-9
Variegated minnow	*Cyprinodon variegatus*		8-10-94	6-9
Atlantic silversides	*Menidia menidia*		8-11-93	6-10
			8-10-94	6-9

[a] Only three turtles were actually seen. Remaining observations are based on nests found on higher elevations of the beach.
[b] Fish collections were qualitative. Numbers of fish collected were not recorded.

Table 9
List of Mammal Species Observed in 1993-1994

Common Name	Scientific Name	No.	Date	Transect No.
White-tailed deer	*Odocoileus virginianus*		8-4-93	8[1]
			8-19-93	9-11[1]
			8-30-93	7-11[1]
			2-2-94	4, 7-11[1]
		4	2-5-94	2
Meadow vole	*Microtus pennsylvanicus*	1	8-19-93	5
Red fox	*Vulpes fulva*		12-8-93	7-10[1]
Grey fox	*Urocyon cinereoargenteus*		12-8-93	7-11[1]
			2-2-94	5
Raccoon	*Procyon lotor*		2-2-94	7[1]
			6-1-94	7-11[1]

[1] Only tracks observed.

Table 10
List of Invertebrate Species Collected During Each Season (Habitats Sampled were High Marsh, Low Marsh, and Shallow Water)

Taxa	No.	Location	Season
No organisms present		High marsh	Summer 93
No organisms present		Low marsh	Summer 93
No organisms present		Shallow water	Summer 93
No organisms present		High marsh	Fall 93
No organisms present		Low marsh	Fall 93
No organisms present		Shallow water	Fall 93
Arthropoda			
Diptera larvae	2	High marsh	Winter 93
Arthropoda			
Diptera larvae	1	Low marsh	Winter 93
Annelida			
Heteromastus filiformis	3	Shallow water	Winter 93
Annelida			
Marenzellaria viridis	1	High marsh	Spring 94
Arthropoda			
Coleoptera sp.	2	High marsh	Spring 94
Coleoptera nymph	2	High marsh	Spring 94
Annelida			
Heteromastus filiformis	1	Low marsh	Spring 94
Crustacea			
Monoculodes sp.	1	Low marsh	Spring 94
Talorchestia longicornis	1	Low marsh	Spring 94
Arthropoda			
Coleoptera sp.	1	Low marsh	Spring 94
Annelida			
Heteromastus filiformis	6	Shallow water	Spring 94
Marenzellaria viridis	16	Shallow water	Spring 94
Laeonereis culveri	2	Shallow water	Spring 94
Leitoscopolos sp.	1	Shallow water	Spring 94
Crustacea			
Lepidactylus dytiscus	9	Shallow water	Spring 94
Leptocheirus plumulosus	1	Shallow water	Spring 94
Monoculodes sp.	2	Shallow water	Spring 94
Arthropoda			
Coleoptera sp.	20	High marsh	Summer 94
Coleoptera nymph	4	High marsh	Summer 94
Hemiptera			
Hemiptera nymph	7	High marsh	Summer 94

(Continued)

Table 10 (Concluded)

Taxa	No.	Location	Season
Diptera			
Diptera pupae	1	High marsh	Summer 94
Diptera larvae	1	High marsh	Summer 94
Arachnida			
Arachnida	1	High marsh	Summer 94
Annelida			
Oligochaeta	3	Low marsh	Summer 94
Neanthes succinea	2	Low marsh	Summer 94
Streblospio benedicti	1	Low marsh	Summer 94
Mediomastus ambiseta	1	Low marsh	Summer 94
Nemertinea			
Nemertinea	23	Low marsh	Summer 94
Nemertinea			
Carinoma tremaphorus	2	Shallow water	Summer 94
Annelida			
Oligochaeta	5	Shallow water	Summer 94
Marenzellaria viridis	8	Shallow water	Summer 94
Neanthes succinea	3	Shallow water	Summer 94
Heteromastus filiformis	20	Shallow water	Summer 94
Strepblospio benedicti	12	Shallow water	Summer 94
Laeonereis culveri	6	Shallow water	Summer 94
Nemertinea			
Carinoma tremaphorus	2	Shallow water	Summer 94
Gastropoda			
Sayella chesapeaka	1	Shallow water	Summer 94
Bivalvia			
Macoma mitchelli	10	Shallow water	Summer 94
Rangia cuneata	1	Shallow water	Summer 94
Crustacea			
Cyathura polita	2	Shallow water	Summer 94
Edotea tribola	2	Shallow water	Summer 94
Corophium lacustre	1	Shallow water	Summer 94
Arthropoda			
Coleoptera sp.	1	Shallow water	Summer 94

Appendix A
1993 and 1994 Dredged Material Beach Profiles

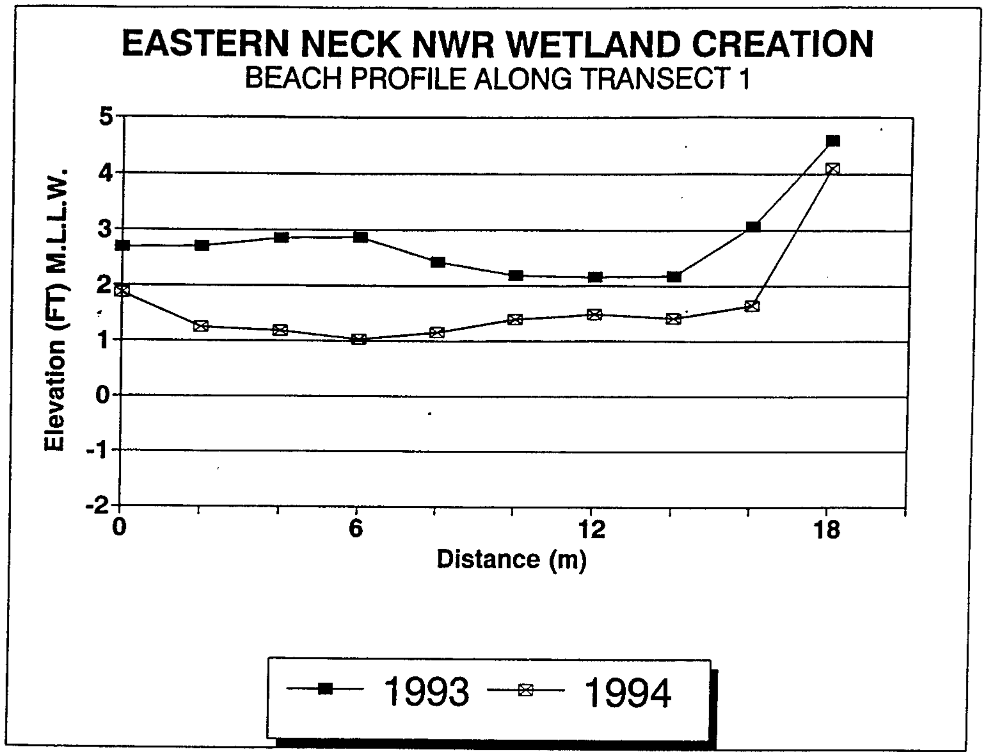


Figure A1. Beach profile along Transect 1

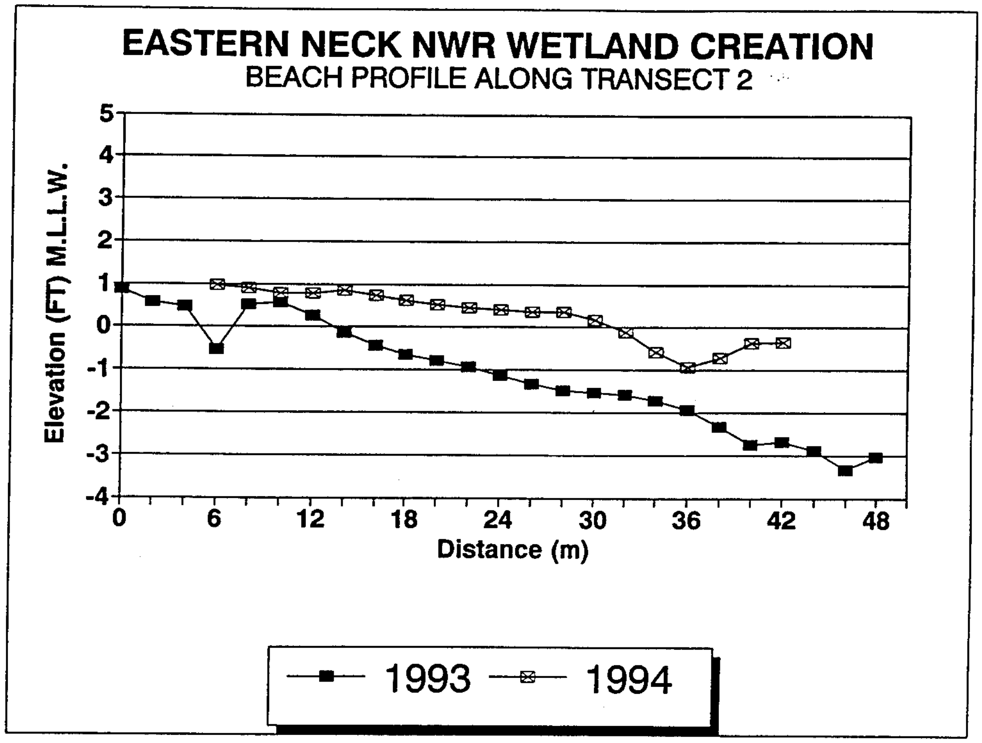


Figure A2. Beach profile along Transect 2

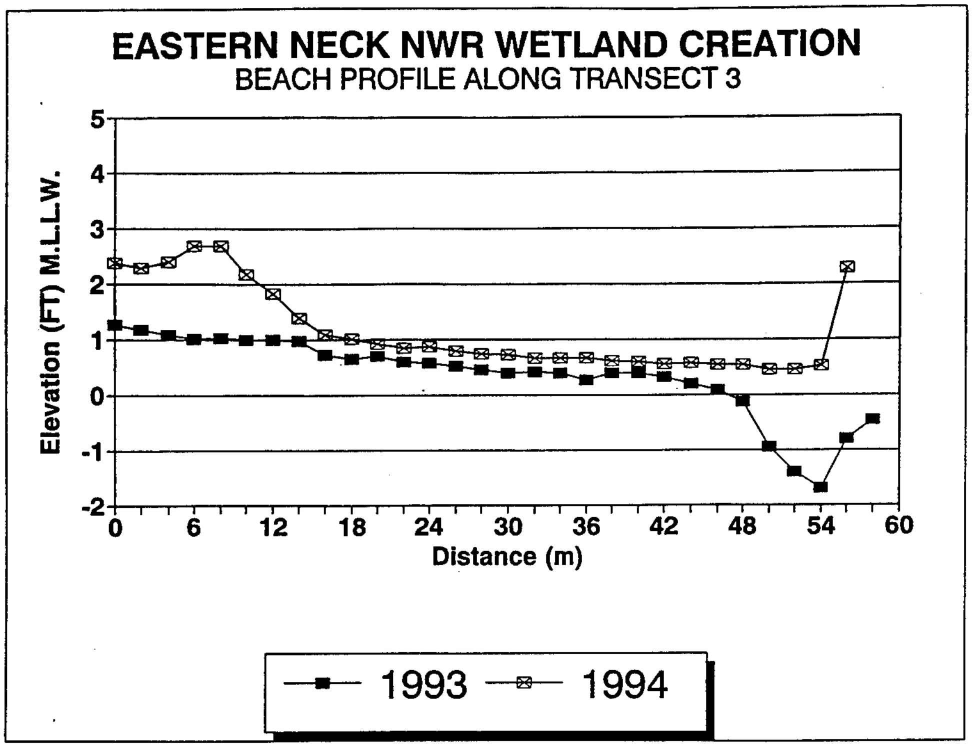


Figure A3. Beach profile along Transect 3

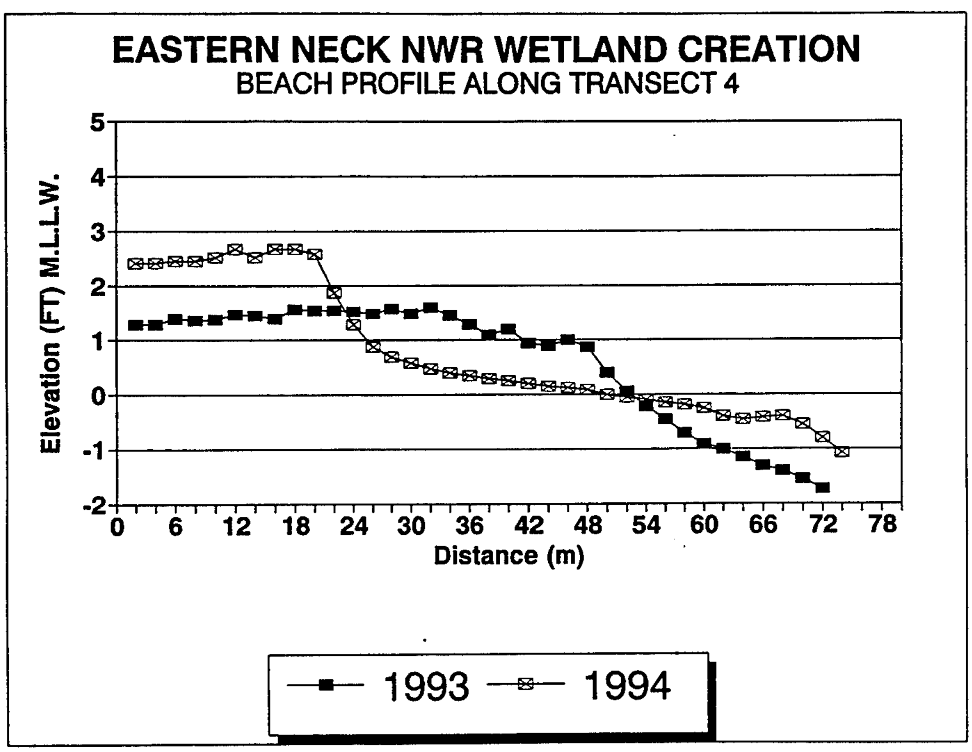


Figure A4. Beach profile along Transect 4

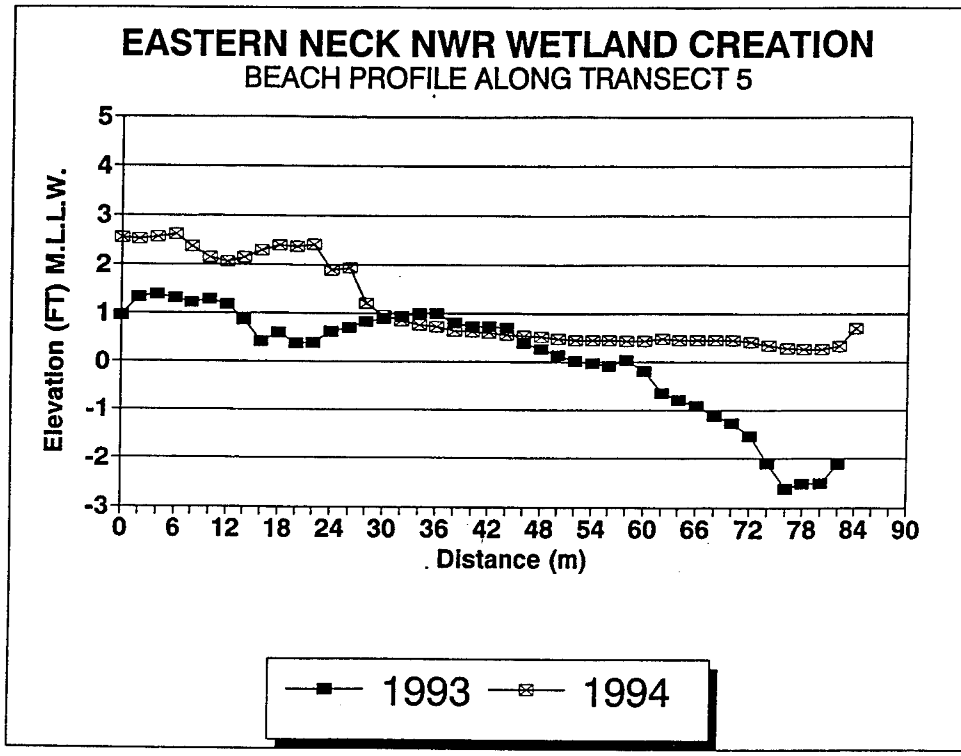


Figure A5. Beach profile along Transect 5

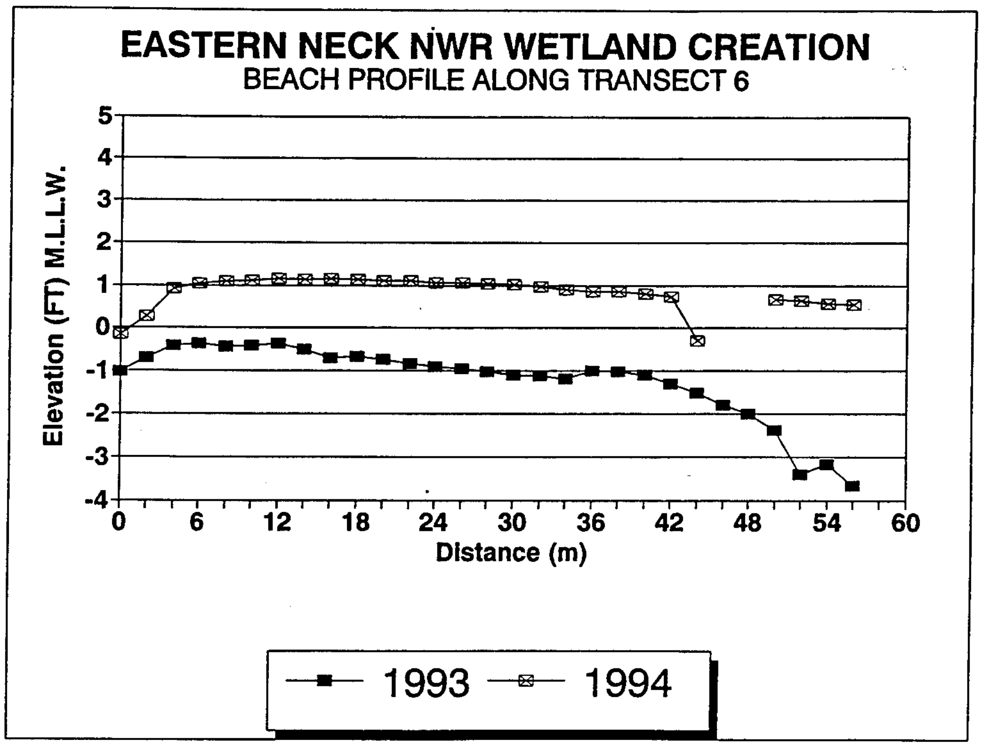


Figure A6. Beach profile along Transect 6

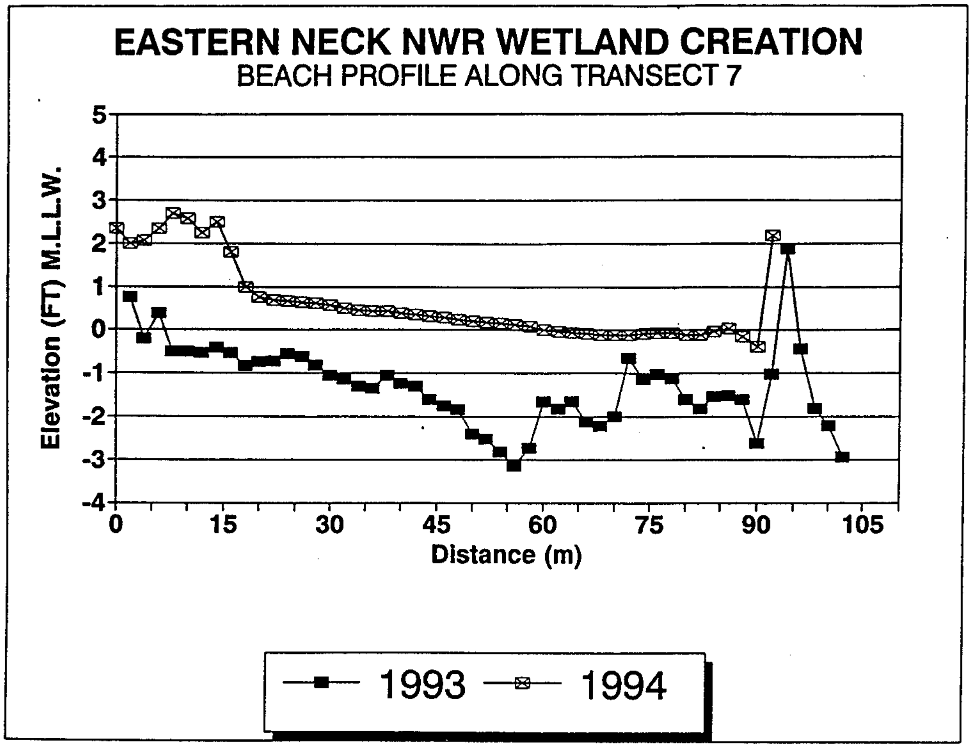


Figure A7. Beach profile along Transect 7

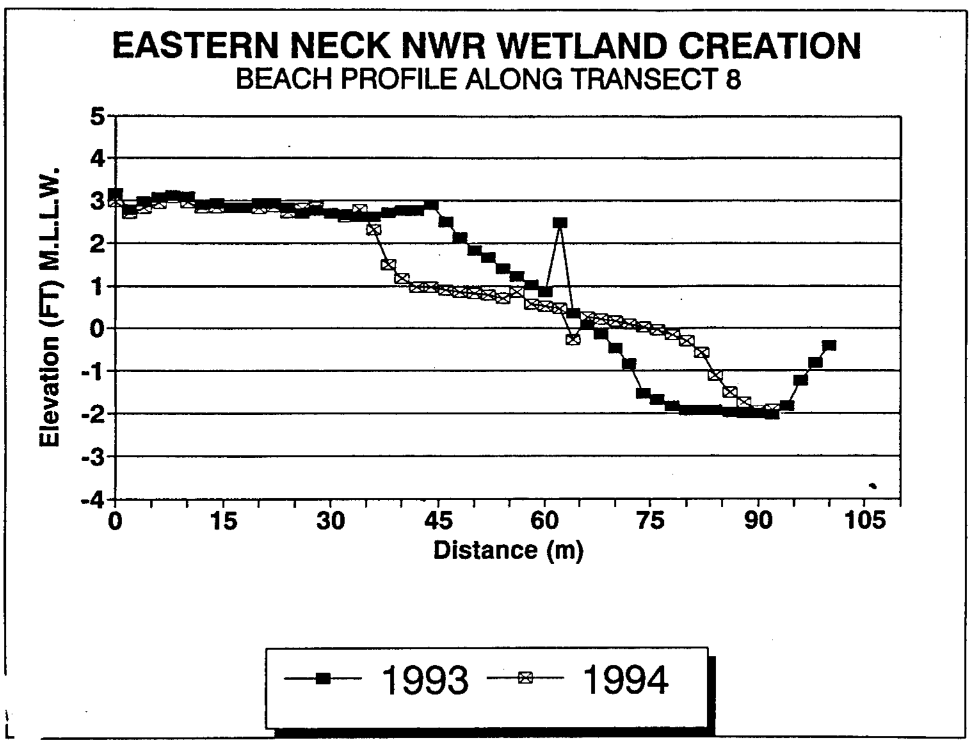


Figure A8. Beach profile along Transect 8

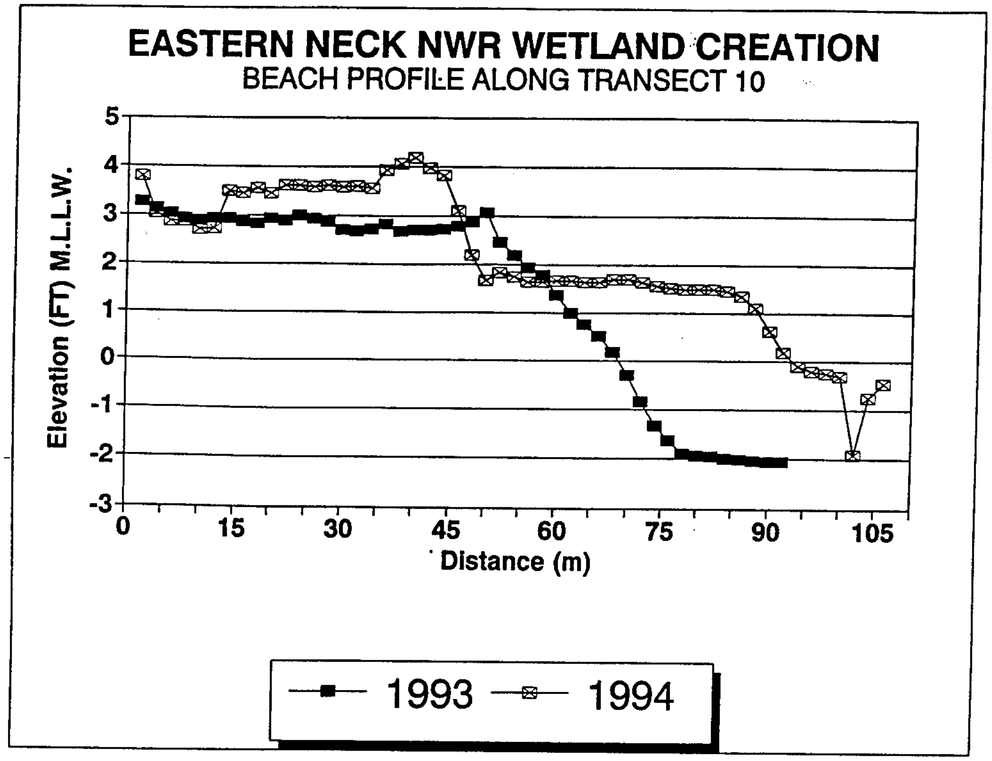


Figure A9. Beach profile along Transect 10

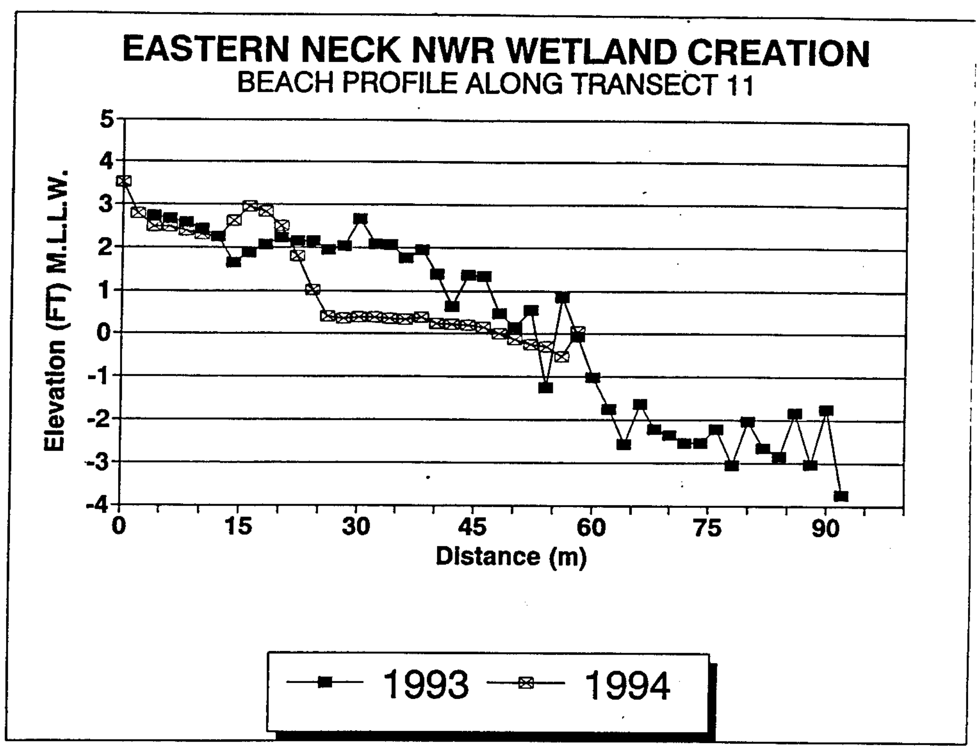


Figure A10. Beach profile along Transect 11

Appendix B
Habitat Analysis

The following abbreviations are used to describe habitat categories:

SWU = Shallow Water Unvegetated
SWV = Shallow Water Vegetated
UB = Unvegetated Beach
LM = Low Marsh—smooth cordgrass zone
HM = High Marsh—saltmeadow hay zone
P = Phragmites

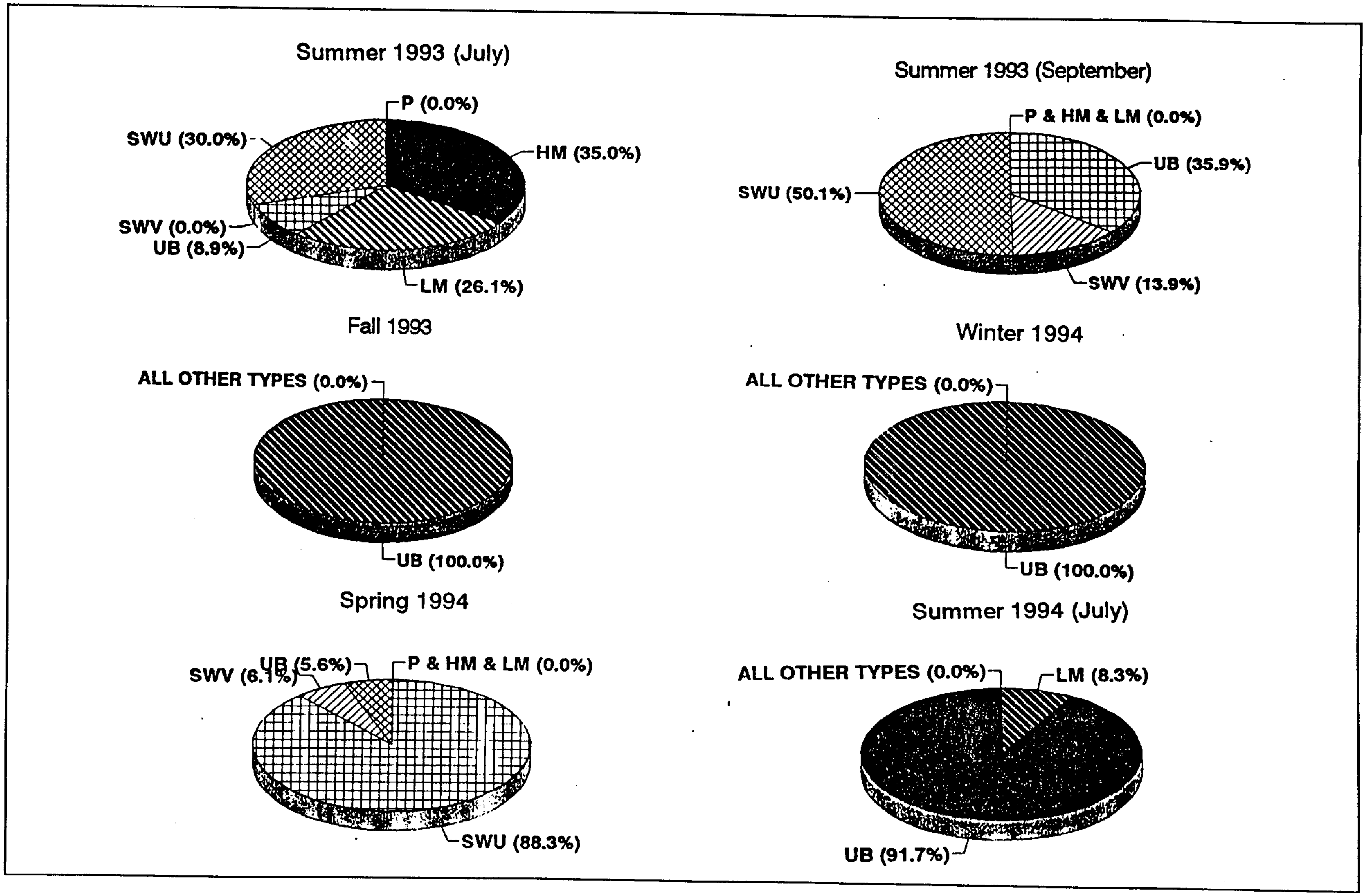


Figure B1. Transect 1

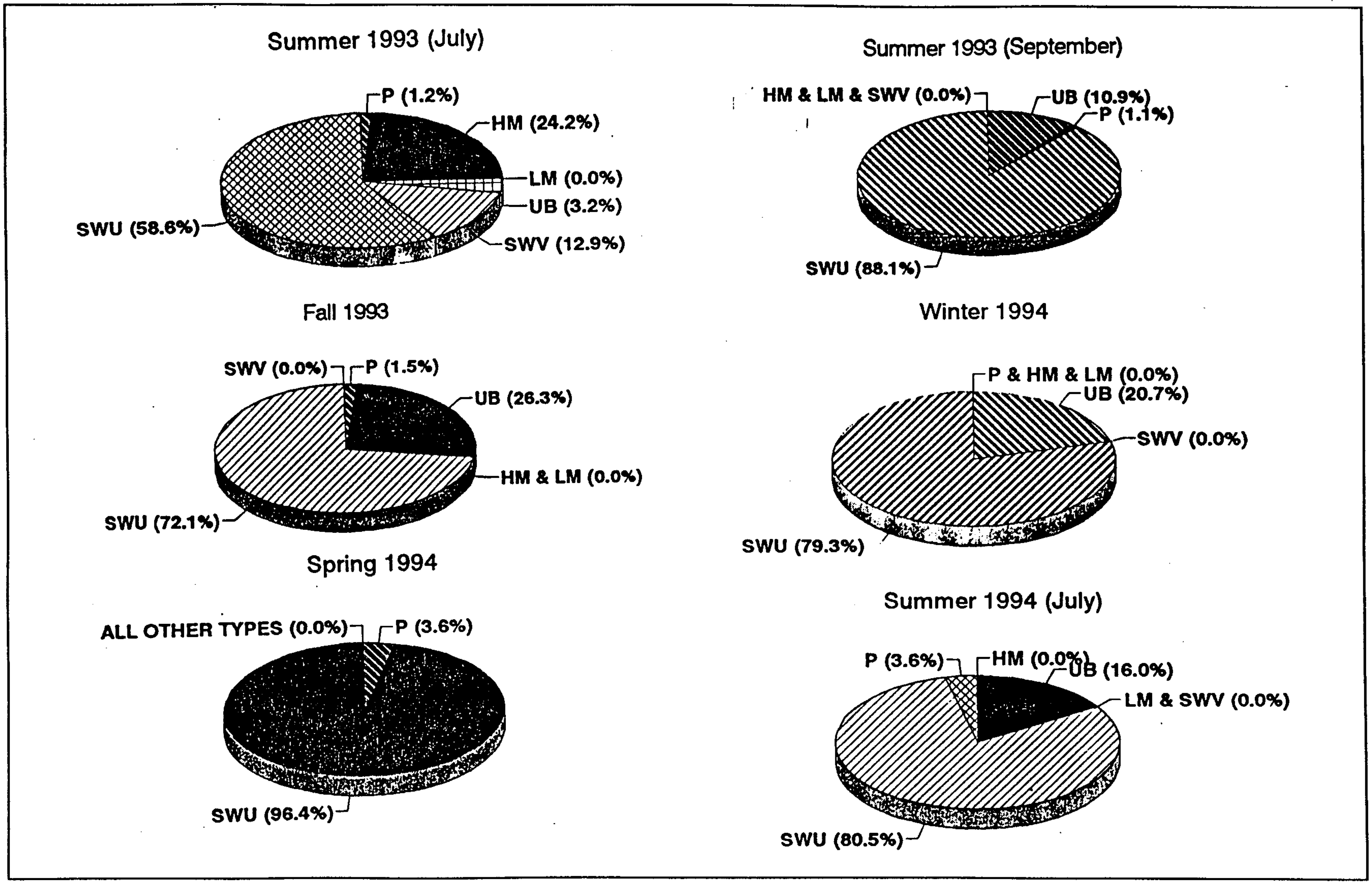
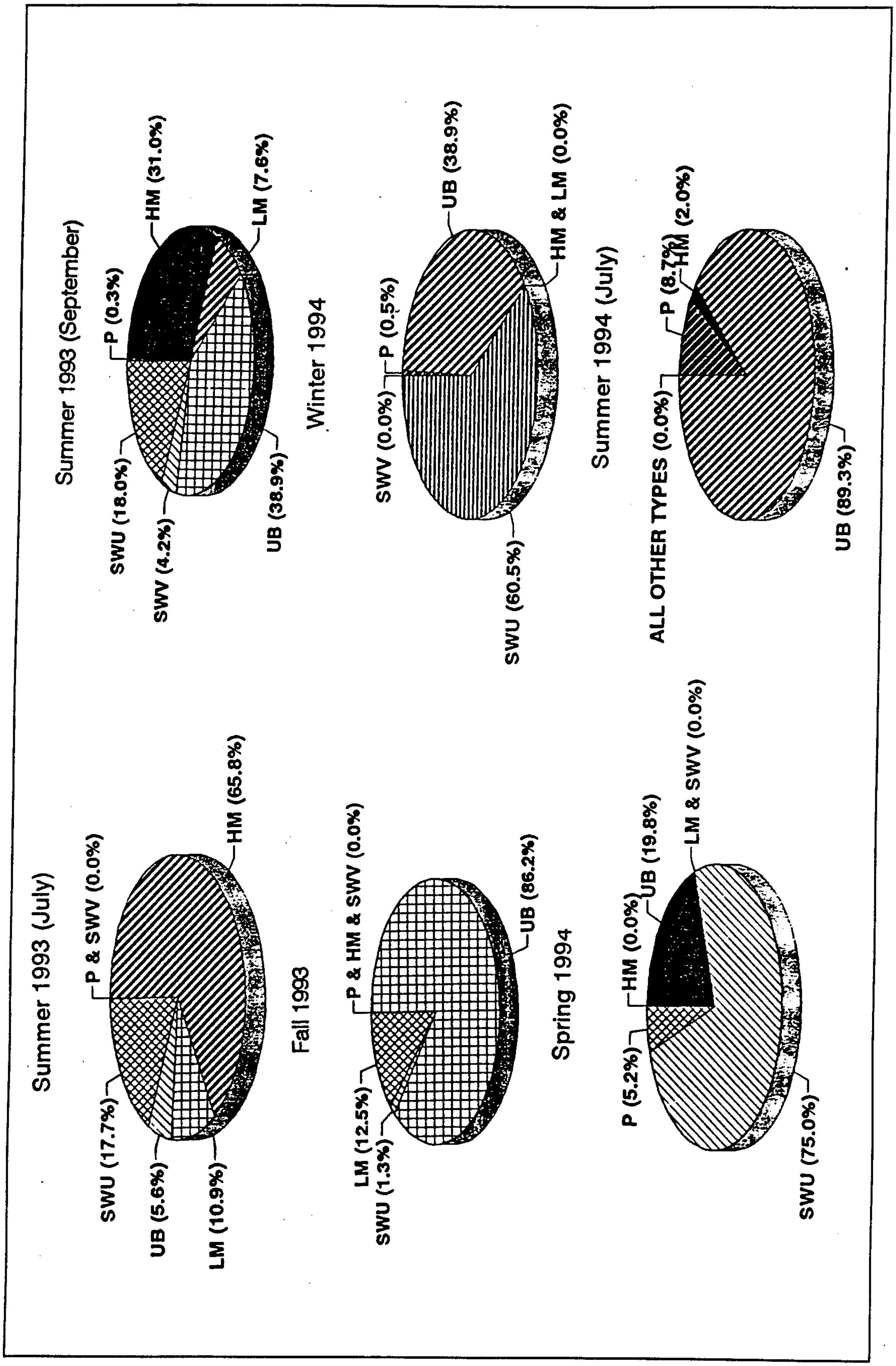


Figure B2. Transect 2



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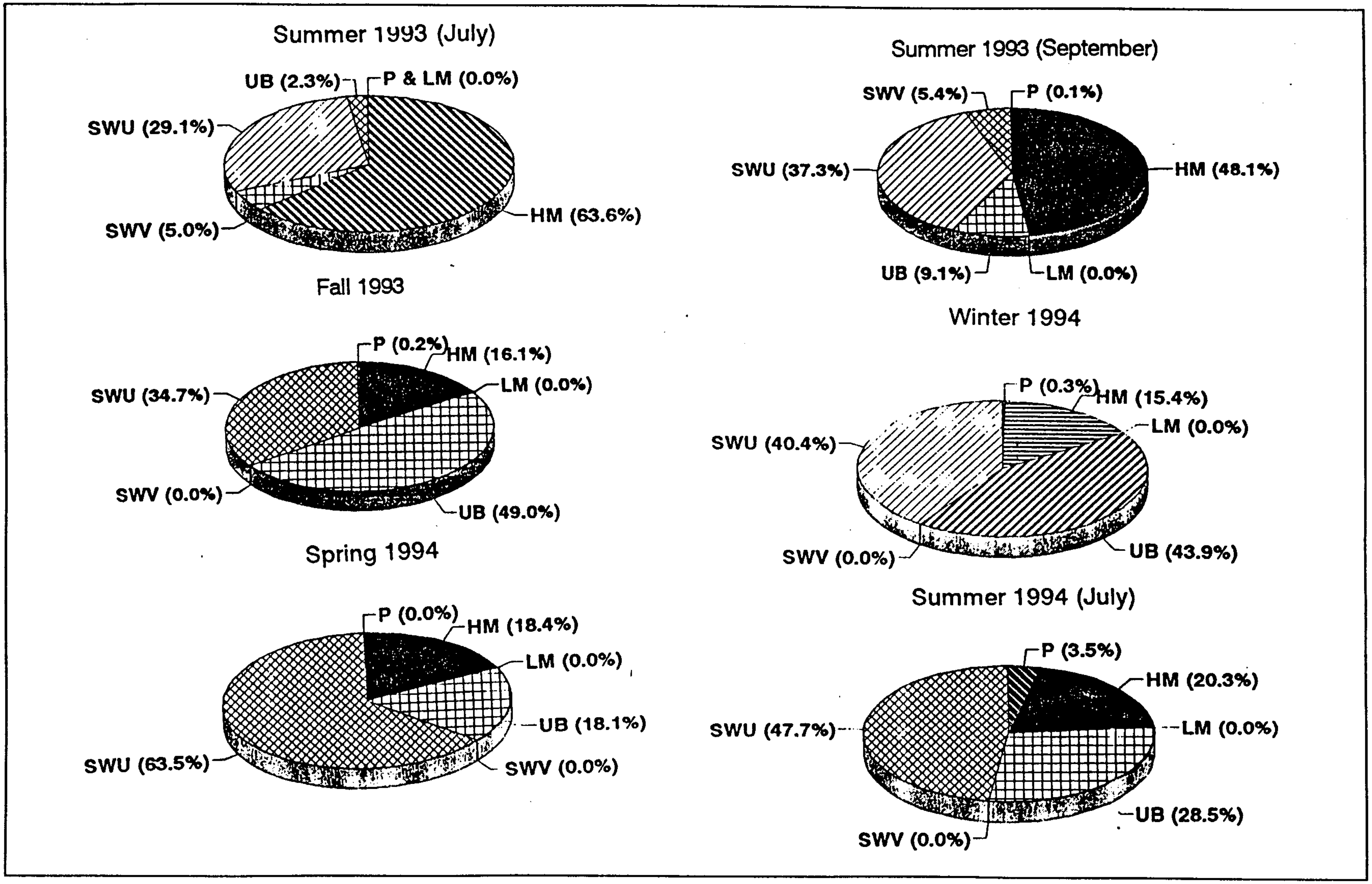


Figure B4. Transect 4

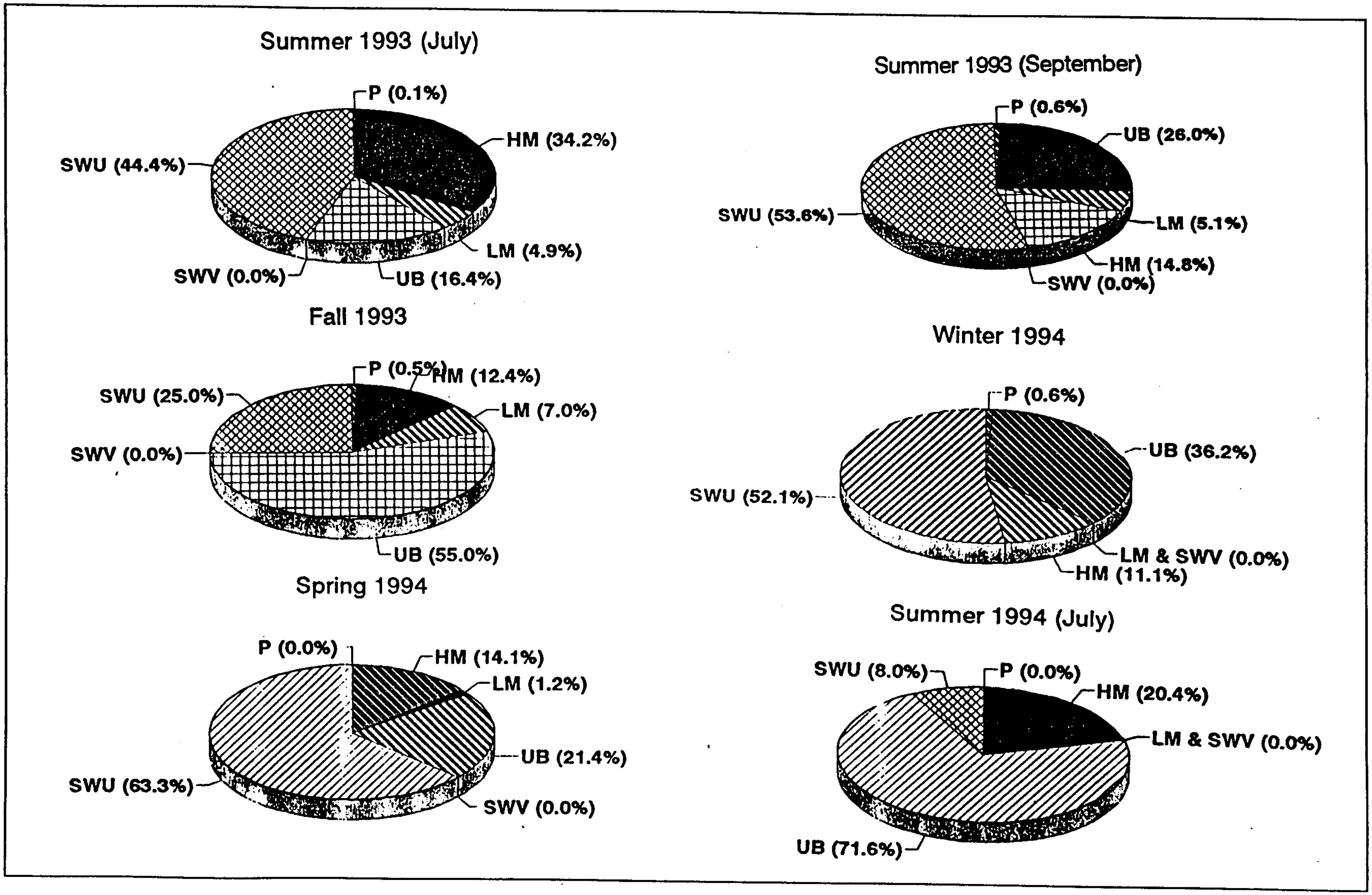
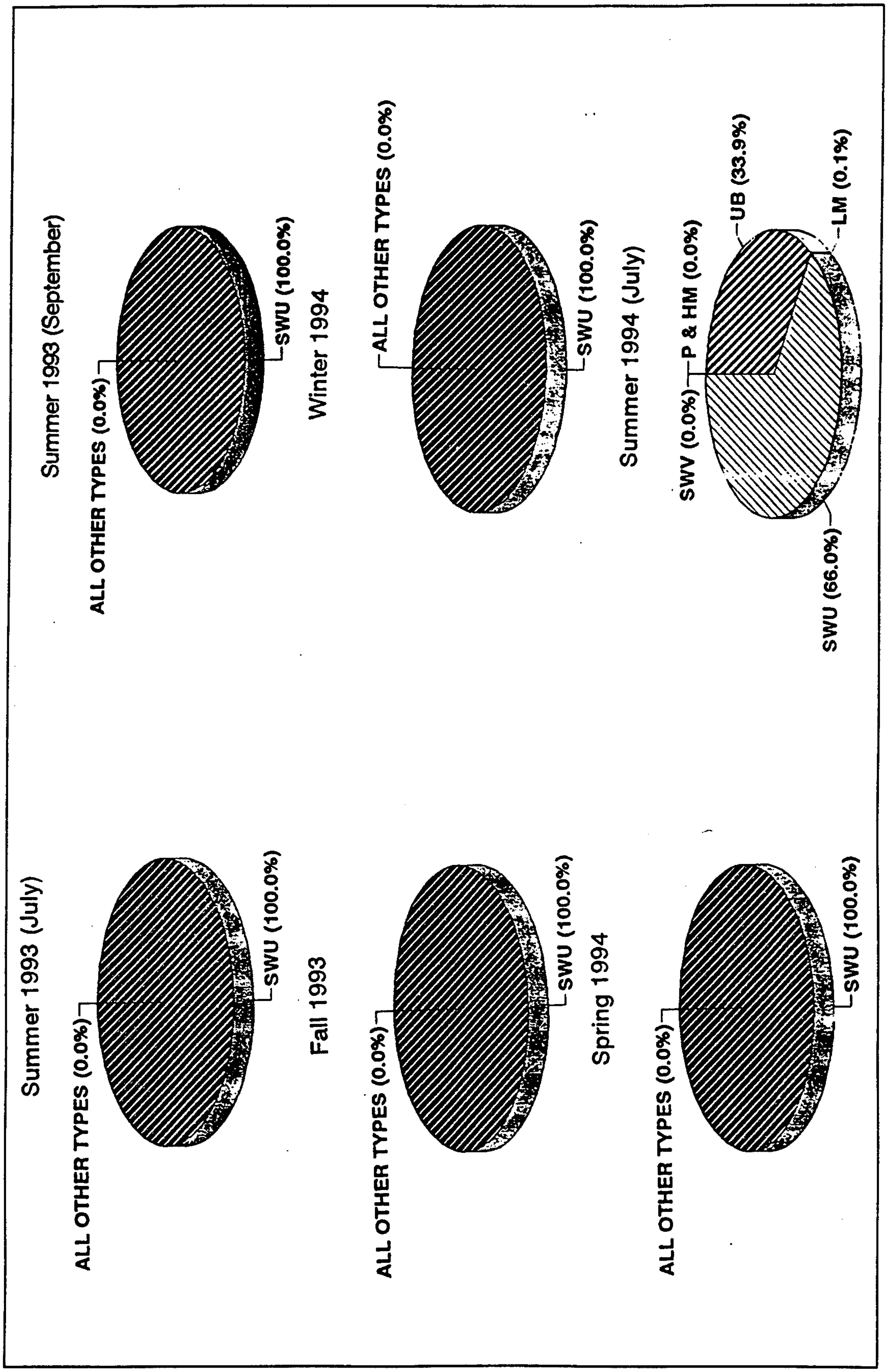


Figure B5. Transect 5



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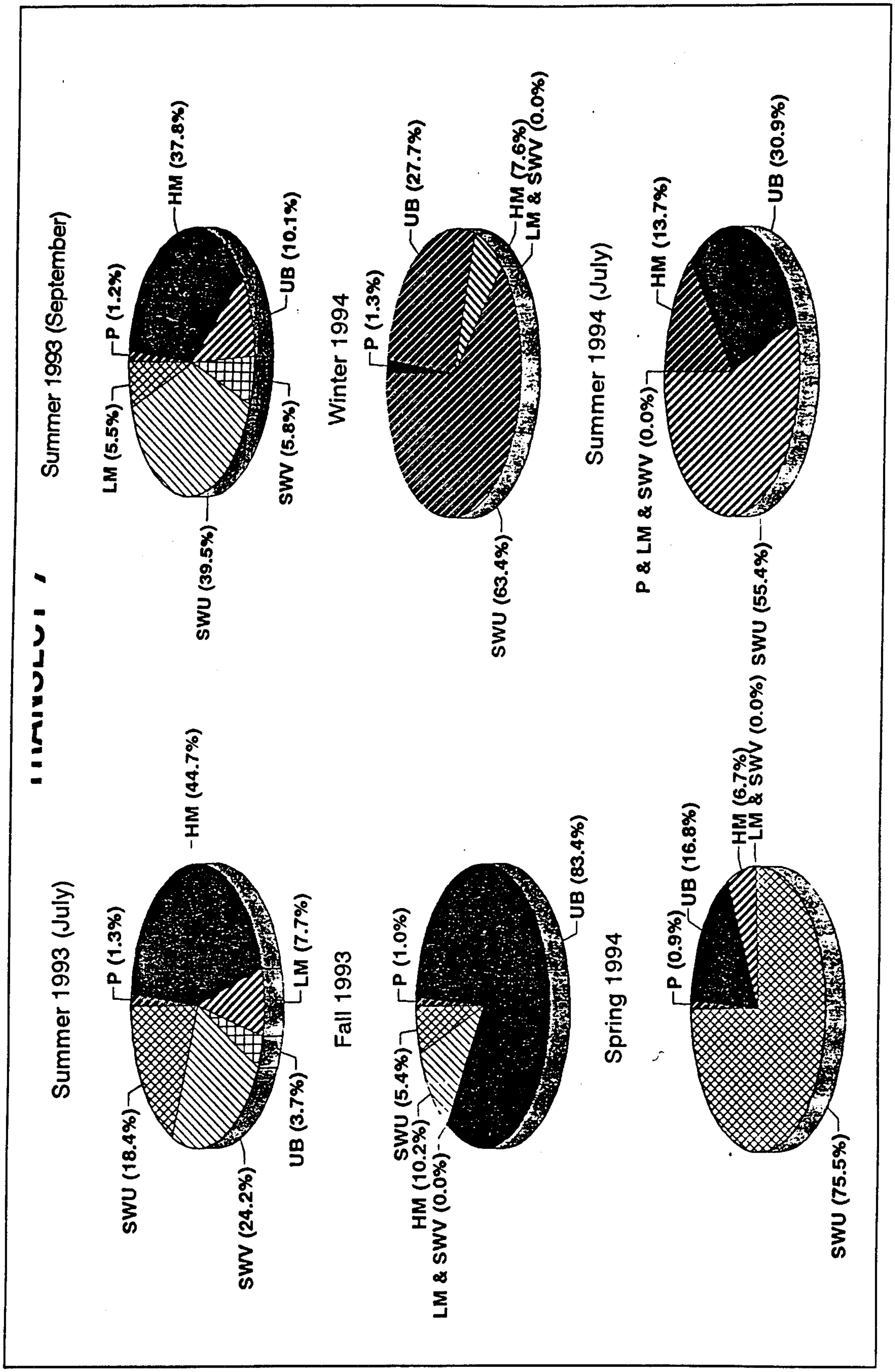

Figure B7. Transect 7

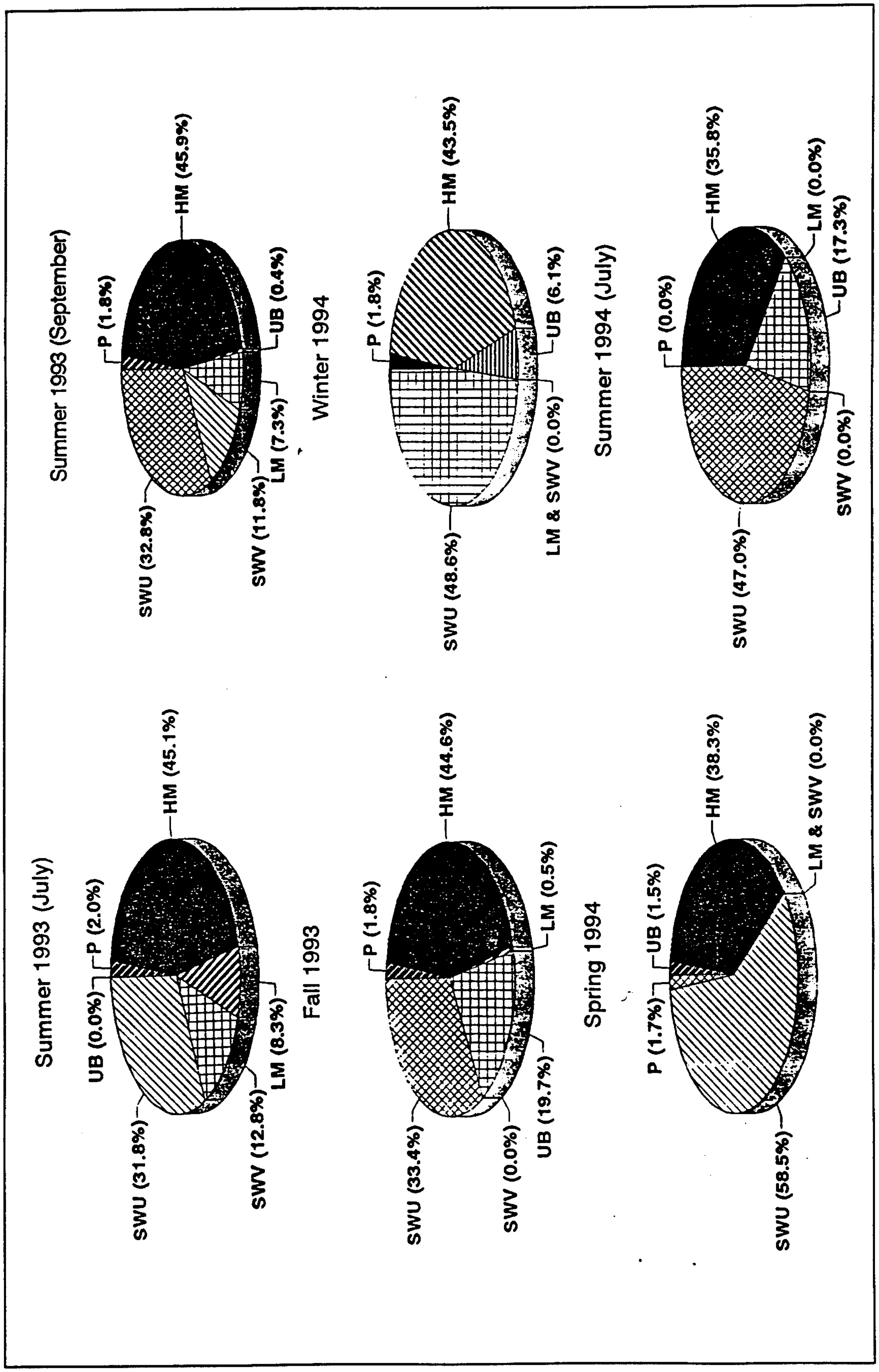

Figure B8. Transect 8

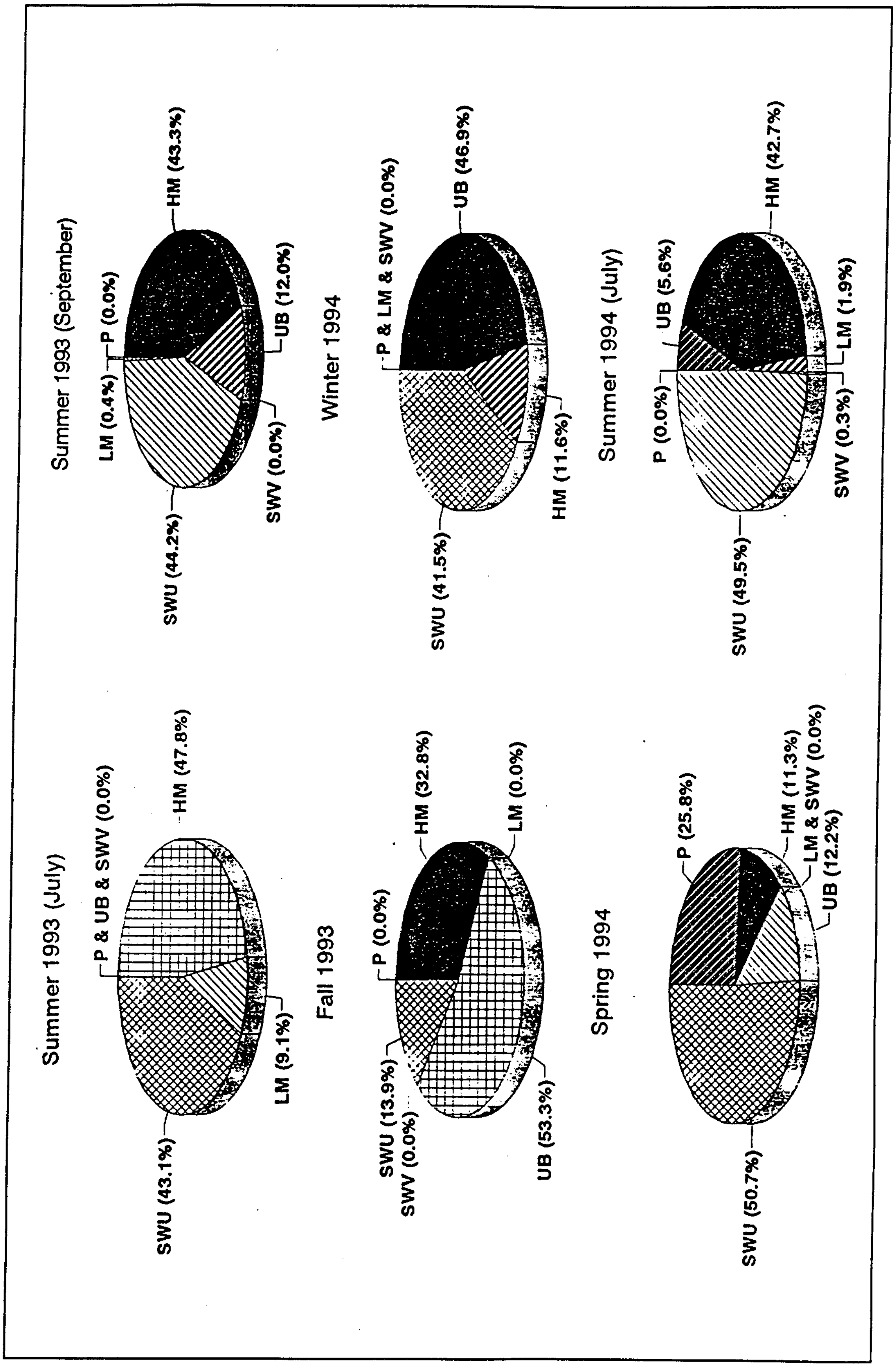

Figure B9. Transect 9

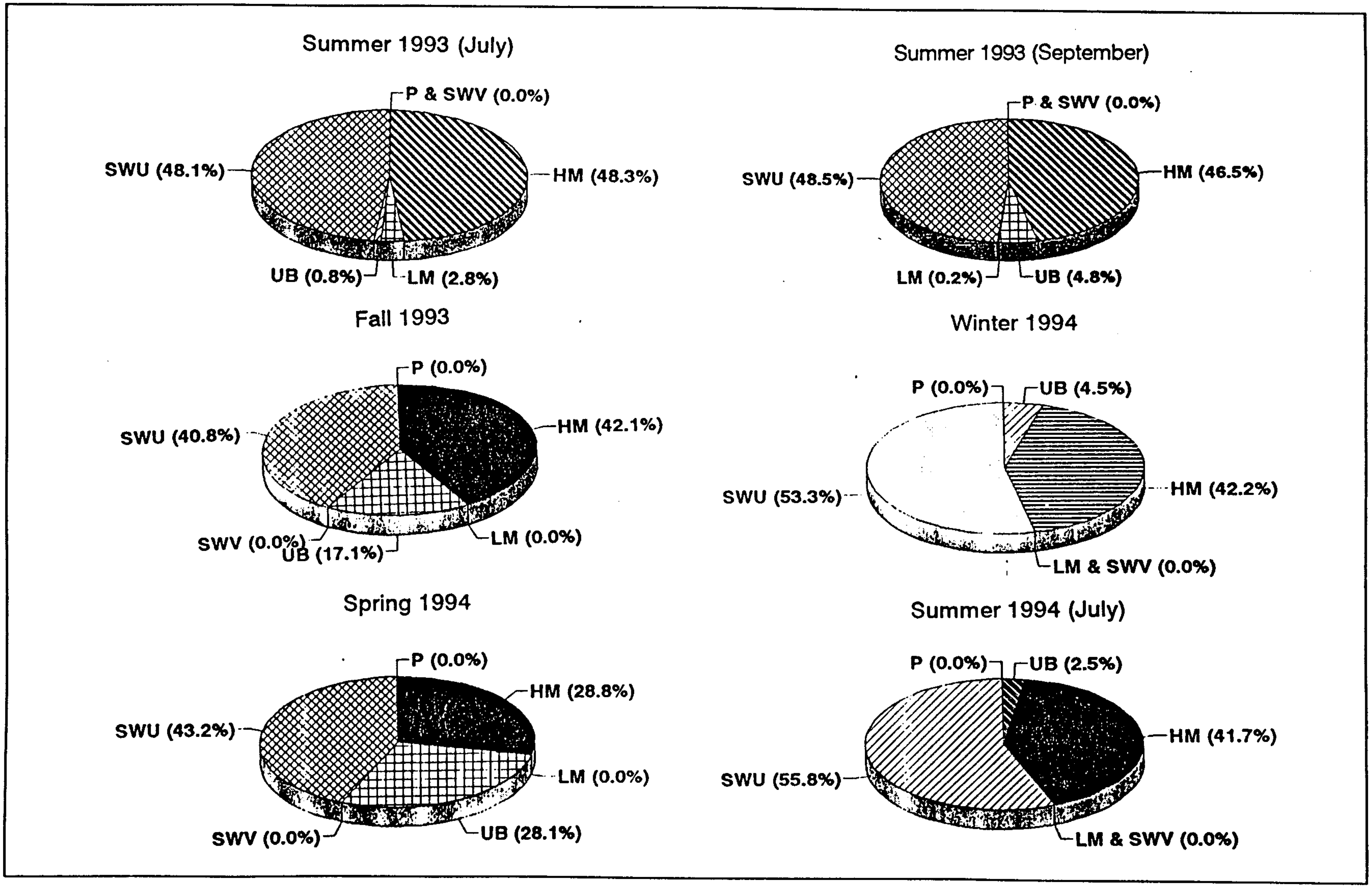

Figure B10. Transect 10

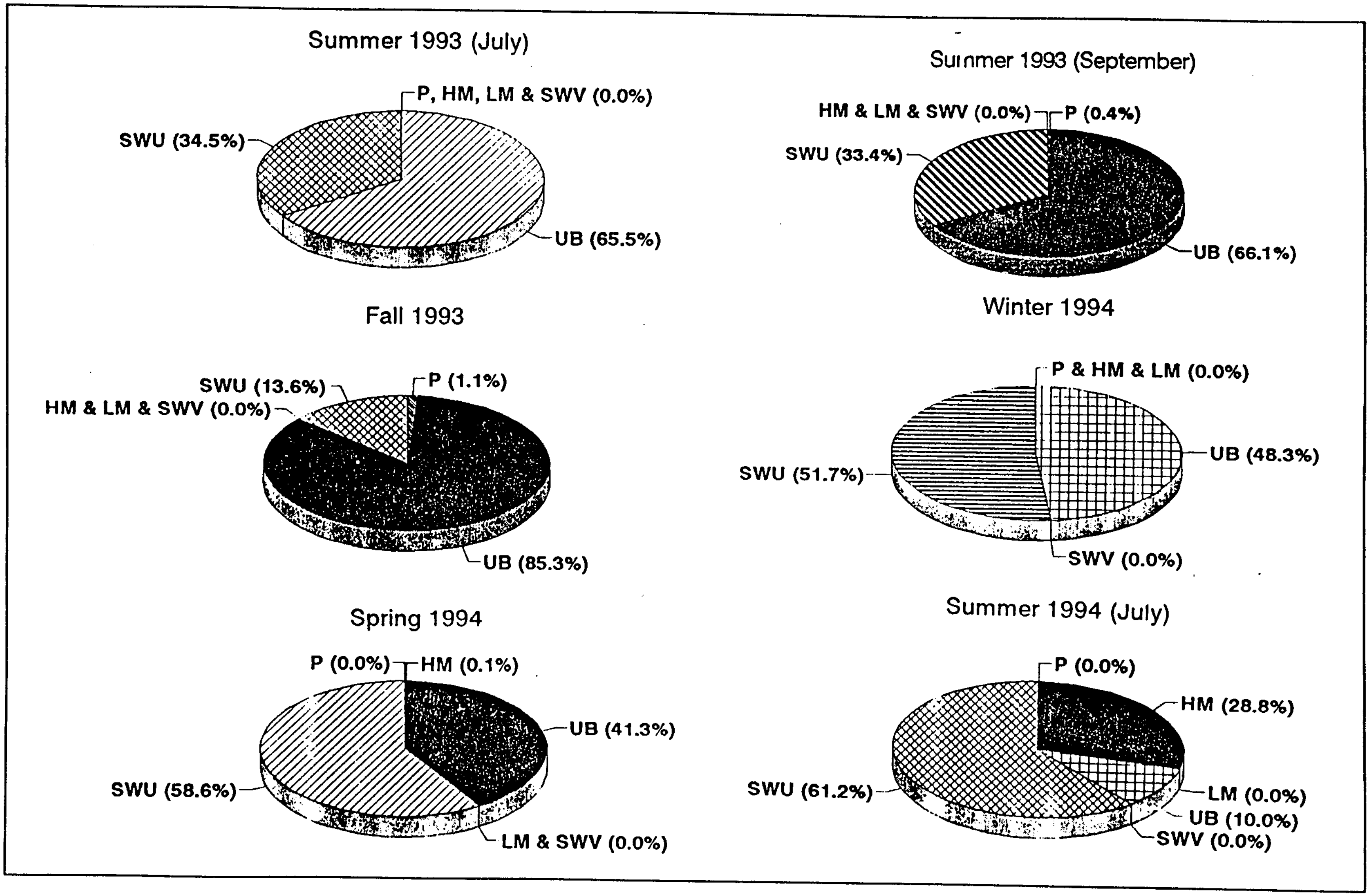

Figure B11. Transect 11

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John W. Gill
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Leslie E. Gerlich

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13. ABSTRACT *(Maximum 200 words)*

Eastern Neck Island National Wildlife Refuge was selected as a demonstration site for the construction of a wetland creation and erosion control project incorporating "beneficial use" of dredged material. Fine-grained, sandy dredged material was used to construct 2.02 hectares of estuarine, emergent wetland. Project objectives were to (a) provide an environmentally preferable alternative to unconfined, overboard dredged material disposal; (b) stop or minimize erosional losses of ecologically valuable habitats; and (c) create wetland habitat. This monitoring study covering two growing seasons was undertaken to determine if project objectives had been met and the potential for expanded application of beneficial uses of dredged material in Chesapeake Bay. Modifications to the erosion control design used at Eastern Neck could improve dredged material stability. Changes in plant materials and planting methods could improve the rate of wetland habitat development. Fish and wildlife utilization of created habitats included 19 species of birds, 2 species of reptiles, 12 species of fish, and 5 species of mammals. Study findings suggest the approach used at Eastern Neck, with modification, could be applied elsewhere in Chesapeake Bay for habitat protection and creation.

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